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SURGERY Gynecology and Obstetrics

With International Abstracts of Surgery

VOLUME 84 January, 1947 NUMBER 1

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[1] Watson, B. P.: J. Clin. Endocrinology 4:571 (Dec.) 1944.

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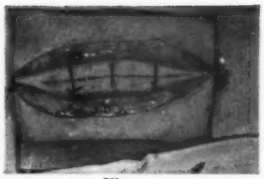
Fig. 2.



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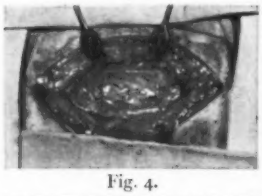

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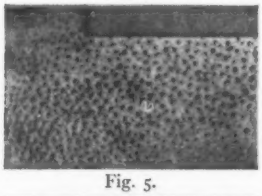

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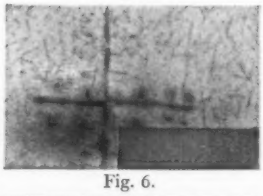

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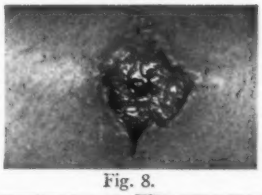

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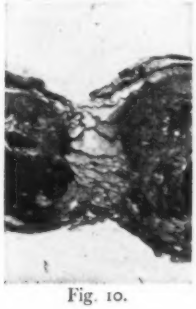

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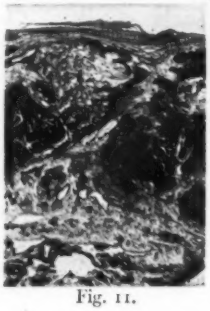

Fig. 11.

Fig. 12.

Fig. 13.

An Experimental Study in Wound Healing in Vitamin C Depleted Human Subjects.—John A. Wolfer, Chester J. Farmer, Walter W. Carroll, and Donald O. Manshardt.

SURGERY
GYNECOLOGY AND OBSTETRICS

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AN EXPERIMENTAL STUDY IN WOUND HEALING IN VITAMIN C DEPLETED HUMAN SUBJECTS

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THE study of wound healing has been the subject of much thought through the ages, but it is only in recent years that surgeons have become acquainted with tangible evidence concerning the value of certain systemically acting biochemical factors. Both clinical and laboratory observations have shown conclusively that the rate and efficiency of primary wound healing depend to a great extent upon the vitamin C (ascorbic acid) content and the protein concentration in the tissues, while to a lesser degree upon carbohydrate and some mineral metabolism. Such conclusions have been drawn by eliminating the well known local deterrent factors of wound healing. There has been satisfactory laboratory evidence cited in the literature to prove the rôle played by vitamin C through animal experimentation, but the data obtained from clinical observations have been of necessity impure and incomplete. By this we mean that a condition in which there is a deficiency of a single vitamin as the only factor (pure mon-avitaminosis) is a rarity, whereas the usual instance is that of a patient presenting a poor nutritional status with multiple avitaminoses, a depletion in serum proteins and a distorted metabolism. Thus, the early observations on impaired wound healing dealt with multiple deficiencies (2, 7, 8, 16, 22, 25, 27, 28), and it was eventually necessary to use animal experimentation to differentiate the factors which were due to a hypoproteinemia and those due to a vitamin C deficiency.

There has been some thought that the part played by vitamin C in human wound healing is overshadowed in importance by other mechanisms on the assumption that the human

The experimental work described here is part of an investigation conducted under a contract recommended by the Committee on Medical Research between the Office of Scientific Research and Development and Northwestern University.

Fig. 1. Skin and fascial incisions with silk sutures in latter.

Fig. 2. Skin incision closed with silk sutures.

Fig. 3. Biopsy of skin wound by elliptical excision.

Fig. 4. Biopsy of fascial wound by rectangular excision *in toto* of healing suture line.

Fig. 5. Perifollicular petechial pigmentation in depleted subject following soap and water skin cleansing.

Fig. 6. Primary healing of cruciate skin closure in subject 5 (W. R.).

Fig. 7. Failure of wound healing after cruciate skin closure in depleted subject 1 (D.A.).

Fig. 8. Same in depleted subject 6 (L.M.).

Fig. 9. Same in depleted subject 8 (J.M.).

Fig. 10. Fascial suture line of depleted subject 8 (J. M.) at 11 days. Photomicrograph reveals lack of blue-staining collagen immediately within the healing zone. (Zenker-Mallory stain).

Fig. 11. Fascial suture line of control subject 11 (D.G.) at 7 days. Photomicrograph reveals abundant light blue staining collagen throughout the suture line.

Fig. 12. Skin suture line of depleted subject 8 (J.M.) at 11 days. Photomicrograph reveals again the lack of collagen throughout the healing zone except for the slight deposition just next to the epithelium.

Fig. 13. Skin suture line of control subject 13 (I.C.) at 10 days. Collagen is to be seen diffusely throughout the suture line.

safety factor is such that the tissue content could not be sufficiently reduced. Concerning this point, we must remember that the human organism cannot synthesize vitamin C. Thus, since the healing of a wound is something of a body emergency, it is logical to expect reserves of necessary substances in the body to be mobilized on the demand of a healing wound. The work of Lauber and Rosenfeld in 1938 showed that in animals on a scorbutic diet many organs lost their vitamin C after the animal had been wounded while vitamin C could be demonstrated in the tissues about the healing wound. Despite this finding of internal chemical balance, the same kind of animal experimentation has revealed a real diminution in tensile strength of the healing wound in those rendered scorbutic. Bartlett (3) in 1942 found the tensile strength to be directly proportionate to the vitamin C content of the scar tissue tested.

Such work as just referred to should not lull us into a sense of false security because even though the tissues in greatest need of vitamin C may receive top priority in order to obtain satisfactory healing, it may be inferred that other parts of the body suffer proportionately by its absence. Workers in this field have shown that in the human subject some signs of clinical scurvy can be obtained after 4 months of a strict deficiency diet, while 6 months' abstinence produces further changes. Both the total daily intake of vitamin C and the duration of inadequate intake are important in developing symptoms, and it has been concluded, with the aid of guinea pig experiments, that changes effected by a complete scorbutic diet of short duration can be reduplicated in humans by administration of a substandard dose over long periods of time. Thus, it is logical to conclude that the effect of this deficiency in wound healing may be more widespread in our population than was originally suspected. To our knowledge, Crandon's study (9, 10) on wound healing in a man completely deficient in vitamin C for a number of months has not been duplicated before this report. In that instance, the subject had been on a diet completely deficient in vitamin C for 3 months, and after the plasma vitamin C had been nil for 44 days, biopsy material from a small wound showed satisfactory healing on the tenth postoperative day. The usual criteria of abundant intercellular substances and capillary formation were used as histological evidence of healing. In the same individual after 6 months on the deficient diet a similar wound showed no signs of healing, as evidenced by a lack of intercellular substances and the presence under the skin of an unorganized bloodclot. No study of tensile strength was carried out in this individual. While this experiment was of great value, the status of the wound never was fully established, for according to Hunt there may be a good supply of intercellular fibers present in a healing wound, nevertheless if most of them are made up of immature collagen, the tensile strength will be quite low.

An opportunity was afforded us to study the effect on wound healing of a prolonged vitamin C deficiency in 9 otherwise normal healthy young males. In addition, 5 normal healthy young males were available as controls. Twelve of these men already have been referred to in a previous abstract (13). Each subject was a medical student who volunteered to submit to a diet deficient in vitamin C for a period of 7 months. The diet was selected from a hospital cafeteria, the foods chosen being free from vitamin C, or subjected to processes destructive to vitamin C, such as overcooking, with or without soda, or by being held on the steam table. Chemical analysis of the whole meals, as well as individual articles of the diet, showed vitamin C to be very low, occasionally 5 to 10 milligrams per day, or entirely lacking. In this respect, our dietetic approach differed from that of Crandon, Lund, and Dill (9, 10), since a civilian might conceivably select a diet similar to ours, but never as severe as that prescribed by the former investigators. Observations were made on the plasma and white-cell platelet vitamin C content, urinary vitamin C excretion, complete blood chemistry, hemoglobin determination and blood cell count, and metabolic urinary constituents. The deficiency status of the experimental subjects was established and maintained throughout the period of observation. At the

end of this time, an incision was made in the thigh through the skin and fascia, and the course of the wound healing studied by removal of biopsy specimens at intervals of 4 to 14 days. This included a measurement of tensile strength of the healing incisions as well as histological examinations of skin and fascia wounds. Immediately after taking the biopsy specimen, saturation tests were done to establish the fact that the tissues of the subjects on the deficiency diets were relatively highly depleted of vitamin C.

DEFICIENCY STATUS

As stated, no attempt was made to place our experimental subjects on as rigorous a dietary regimen as carried out by Crandon. We were interested in the effect of a diet grossly inadequate in ascorbic acid when administered over a prolonged period, upon the severity of depletion of the body vitamin C, and the degree of healing occurring following standardized surgical technique on depleted and undepleted control subjects. We wished to answer the question as to how severe vitamin C depletion must become before marked impairment of the healing process occurred.

All subjects were placed upon a basal diet, adequate in protein, fat, and carbohydrate, but as low in vitamin C as selection and preparation could render it. This diet was also somewhat low in the members of the vitamin B complex, but not to such a degree as to be considered deficient. Subjects subsisting on this basal diet were designated for practical purposes as "vitamin C deficient." A few of these subjects received daily supplements of the members of the B complex in amounts recommended as adequate by the Committee on Food and Nutrition of the National Research Council. The normal control group was placed upon the basal diet supplemented with adequate amounts of the vitamins of the B complex and 75 to 150 milligrams of ascorbic acid daily.

Several methods have been proposed for ascertaining the degree of depletion of vitamin C suffered by the body tissues. These tests, frequently referred to as saturation tests, may be classified, according to technique employed, into the following four groups:

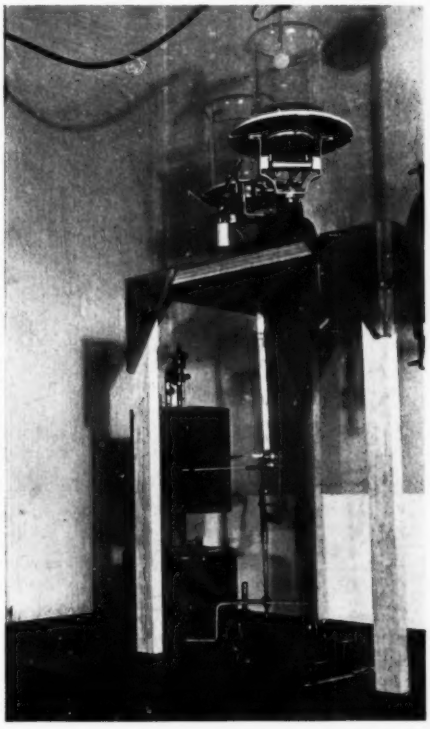

Fig. 14. Tensiometer used to test holding power of measured segment of suture line. Water falling into beaker on right side of balance causes clamp attached to left side to pull away from lower fixed clamp eventually rupturing suture line. Rupture producing force determined by weight of water used.

1. Measurement of the 24 hour urinary excretion of vitamin C after the oral administration of a standard test dose (1).

2. Measurement of the plasma vitamin C rise and urinary excretion after oral administration of a test dose (12, 24).

3. The measurement of the rate of plasma vitamin C drop and urinary excretion in 5 hours following the intravenous administration of a test dose (20, 29).

4. The estimation of the vitamin C content of the white-cell platelet layer may also be used as an index of tissue depletion (6).

Of these tests, the degree of tissue depletion may most readily be determined by the ad-

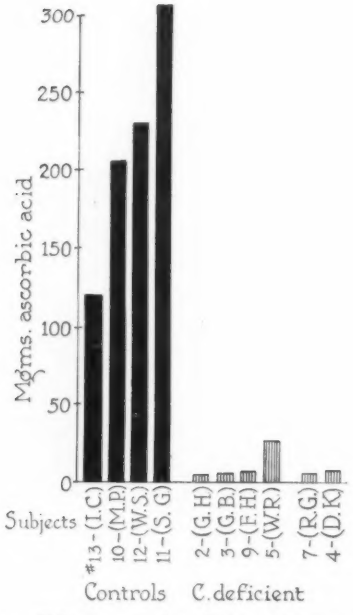

Fig. 15. Urinary excretion during 5 hour saturation test.

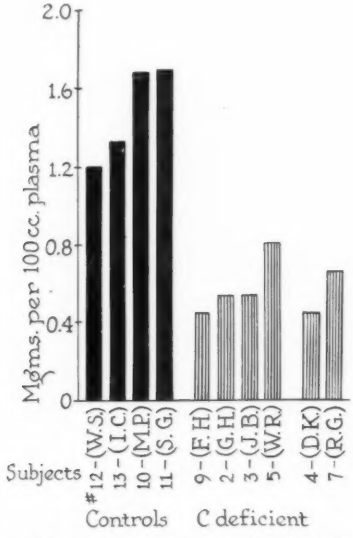

Fig. 16. Magnitude of plasma ascorbic acid rise following saturation test dose of 15 milligrams per kilogram body weight. Data plotted is peak plasma value minus fasting level.

ministration of a standard oral dose of 15 milligrams of vitamin C per kilogram of body weight, and the determination of the blood plasma and urinary vitamin C each hour for 5 hours. The subject empties his bladder, and the first sample of blood is taken. The test dose of vitamin C dissolved in 200 cubic centimeters of water and slightly sweetened if desired is taken immediately. Blood samples, from either the finger or vein, are taken hourly thereafter for 5 hours. The bladder is completely emptied at the time the blood samples are taken. Both blood and urine samples are analyzed (11), and the data plotted as shown in the accompanying charts (Figs. 15, 16, 17, 18).

It is desirable that the saturation test be run on the subject in the fasting state. If not convenient, it may be started 4 hours after a light meal which contains no vitamin C. No food is taken during the test. The subject is permitted a total of 400 cubic centimeters of water as desired to assure sufficient urine for hourly specimens.

White-cell platelet vitamin C was determined periodically during the investigation. The average values for subjects deprived of vitamin C at the time the surgical studies were done were 0.75 milligram per 100 grams white-cell platelet layer; the normal controls averaged 31.85 milligrams per 100.

The plasma total protein levels of all subjects ranged between 6.80 and 7.57 grams per 100 cubic centimeters during the entire study.

SURGICAL PROCEDURE

The left thigh was used throughout. A 6 centimeter longitudinal incision was made over the region in which the fascia lata was suspected of being strongest. The incision first was made through the skin and superficial portion of the subcutaneous layer, thus allowing uniform undermining of the skin 1 centimeter away from the incision in each direction. The incision was then continued to the level of the fascia lata, this being carefully exposed with a minimal of tissue damage. A corresponding 6 centimeter longitudinal incision was then made in the fascia, the edges being allowed to fall apart. Interrupted silk

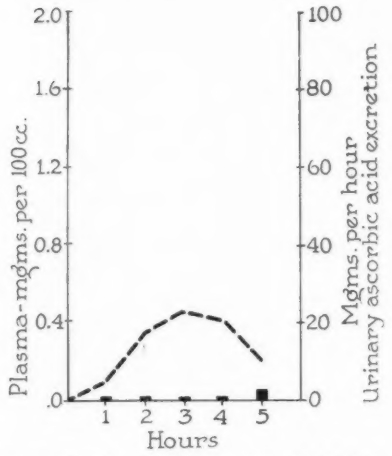

Fig. 17. Vitamin C saturation test. C deficient. November 8, 1942. Weight 63.6 kilograms, dose 954 milligrams, ascorbic acid.

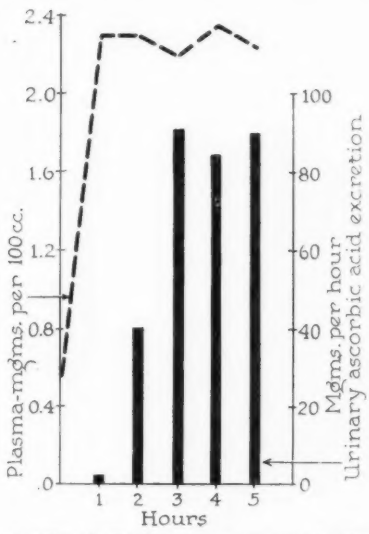

Fig. 18. Vitamin C saturation test—control. November 11, 1942. Weight, 89.8 kilograms. Dose 1350 milligrams ascorbic acid.

sutures were used for closure of both fascia and skin and were placed about 1 centimeter apart so as to obtain perfect apposition. Simple dressings were then applied. During the course of healing, alternate sutures were removed on the fourth day, and the remaining on the sixth or seventh day.

In obtaining the skin specimens for study, two different techniques were used. In 4 cases, a 2 centimeter square block was removed so as to include the suture line in its middle. The closure of the defect was obtained by converting this square into a transverse ellipse, undermining the borders and using interrupted silk sutures under some tension. This, with the former incision, resulted in a cruciate closure with a maximum of interference to the blood supply. In the remaining 10 cases, the original incision was removed in its entirety by an elliptical excision, the closure being accomplished with a minimum of undermining and with interrupted silk sutures under only moderate tension.

In all cases, the specimens of fascia lata were obtained by simple excision of a corresponding 2 centimeter square section of tissue, which included the suture line. No attempt was made to close this defect.

As a routine, all the subjects were admitted to the hospital the evening before the surgical procedure and remained in the hospital for at least 24 hours afterward. Hospitalization was continued much longer in those exceptional cases in which complications developed. All the surgery was carried out in the operating rooms under strict aseptic precautions, the skin preparation being soap and water cleansing for 10 minutes. Exceptions to the latter were made in the secondary operations in those instances in which it was thought that the mechanical rubbing would be deleterious to the wound edges. Routine iodine and alcohol preparation was used in these cases. The anesthetic agent was 1 per cent procaine solution with adrenalin used as a circumferential field block.

The rupture factor. The tensiometer used for the tissue tensile strength determination is shown in Figure 14. The essential feature of this device was a perfectly balanced pair of clamps, which could be separated very slowly by an accurately measured weight of water. The biopsy specimen was held by the soft rubber-cushioned clamps so that the suture line was immediately between and parallel to the clamps. The weight of the clamps was first balanced out and then water was allowed

TABLE I.—SURGICAL STUDIES

Subject No. initials	Tissue	Day of healing	Size of tissue block in mm.	Grams to rupture at suture line	Rupture Factor gms. sq. mm.	
					Skin	Fascia
C Deficient Subjects						
1 D.A.		4th	Too fragile			
2 G.H.	Skin	5th	2.5 x 10	78	3.12	8.36
	Fascia		1.1 x 10	92		
3 J.B.	Skin	6th	2.5 x 10.5	116	4.42	4.18
	Fascia		1.5 x 11	69		
4 D.K.	Skin	7th	2.5 x 9.9	172	6.95	2.07
	Fascia		2.1 x 8.5	37		
5 W.R.	Skin	7th	3.5 x 10	373	10.66	8.54
	Fascia		1.5 x 11	141		
6 L.M.	Skin	9th	2.5 x 10	601	24.04	6.23
	Fascia		1.3 x 10	81		
7 R.G.	Skin	9th	2.2 x 10.2	102	4.51	13.33
	Fascia		1.5 x 9.4	188		
8 J.M.	Skin	11th	2.8 x 10	524	18.71	11.89
	Fascia		1.8 x 8.6	184		
9 A.F.	Skin	14th	2.8 x 10	2025	72.35	36.65
	Fascia		2.2 x 9.3	750		
Controls						
10 M.P.	Skin	5th	2.7 x 11	74	2.49	3.20
	Fascia		1.7 x 9	49		
11 D.G.	Skin	7th	2.0 x 9.9	232	14.74	9.22
	Fascia		1.7 x 10.2	160		
12 W.S.	Skin	7th	2.0 x 10.1	142	7.03	12.00
	Fascia		1.2 x 10	144		
13 I.C.	Skin	10th	2.5 x 8.4	1115	53.09	
14 W.M.	Fascia	10th	1.2 x 11	371		28.1

to drop into the beaker on the opposite side of the balance, the weight of which eventually produced the rupture. Kymographic tracings of this process were simultaneously obtained by the attachment of a pointer to each clamp. The specimens, when first obtained, were immediately placed in normal saline solution and all were tested within 1 hour of their removal from the subject. The tensile strength was measured in grams of water, and a number designated as the rupture factor calculated for each specimen. Thus, the rupture factor is the ratio of the weight in grams required to open the wound at the suture line to the cross-sectional area in square millimeters at the suture line. This latter was obtained with the aid of a vernier caliper. Therefore, the rupture factor equals

$$\frac{\text{grams required for rupture}}{\text{cross-section area in sq. mm.}}$$

All tissue blocks for testing were cut as nearly the same size as possible to diminish the factor of error when making the comparison.

RESULTS

For the sake of simplicity in reporting our results, it seems best to omit the case histories covering the period of primary wound healing because in every instance the appearance of the wound was identical. On the other hand, there were significant changes in the gross course of healing after the biopsies had been obtained, but this we wish to discuss after consideration of the primary tensile strength determinations and the concomitant histological findings.

In each instance, the skin edges were found to be accurately apposed, and the area about the sutures was free of any significant inflammatory reaction. There were no gross differences between the deficient subjects and the controls as regards the quantity of encrusted blood at the suture line, ecchymosis of the skin, or the presence of edema in the tissues. While petechiae did not develop spontaneously in our subjects as a result of vitamin C depletion, two subjects, as a result of the unavoidable slight trauma of presurgical soap and water cleansing with cotton, presented perifollicular pigmented papules similar to the petechiae found in clinical scurvy (Fig. 5). This phenomenon was not observed in the control subjects receiving supplements of ascorbic acid. Soap sensitivity tests were made which proved to be negative.

Table I summarizes the data gathered for the tensile strength determinations. Previous workers in this field (especially with small animals) have been content to compare the force necessary for rupture. In the instance of an entire suture line this would measure its weakest point. If a segmental study were

made, the sections studied will of necessity vary in size (regardless of what cutting technique is used), and thus a strict comparison of force in grams would be of value only when differences are sufficiently great to compensate for the variations in the cross-sectional area of the segment of suture line being tested. For this reason, the ratio of the force to cross-sectional area at the suture line was adopted as a method for comparison. The consistency of the findings reveals a definite trend in both depleted and control groups with but one exception. In this subject (No. 5. W.R.), the skin suture line manifested a strength greater than one of the two comparable controls yet slightly less than the average of both controls. It is also to be noted that his fascia rupture factor approached very closely to the level of the controls, though not exceeding either. While it is interesting that this subject was later found by means of the saturation test to be less depleted in vitamin C than others of his group, it must be recognized that variations in human experimental material as related to inherent differences of tissue turgor, thickness, and personal healing propensities cannot altogether be evaluated or eliminated.

By using the arithmetic mean of the accumulated rupture factors, curves of tissue healing were obtained for both skin and fascia. These curves were a measurement of the tissue repair strength itself and were not complicated by the presence of suture material. Because of the latter factor being eliminated, no attempts to measure the tissue strength were made before the fourth day of healing. A measurable amount of strength was found on the fifth day, and, as seen from the accompanying graphs (Figs. 19 and 20), the wound strength increases through the seventh and tenth days in almost a straight line. By comparison, the wound strength of the deficient subject is seen to be less than that of its control on the corresponding day up and through the eleventh day, following which the tensile strength curves tend to parallel one another. The greatest differences are found between the sixth and tenth days, but the delay in acquisition of healing strength in the deficient subjects extends up to the thirteenth day. The lone deficient subject studied on the fourteenth day revealed satisfactory healing to be occurring but at a delayed rate.

TABLE II.—HISTOLOGICAL DATA

Subject No. Initials	Tissue	No. of days of healing	Reticulum	Collagen	Fibrin	Hemorrhage	Fibrocytes
C Deficient Subjects							
1 D.A.	Skin	4	o	o	+	+++	+
	Fascia		o	+	+++	++	+
2 G.H.	Skin	5	±	o	+	++	+
	Fascia		±	o	++	++	+
3 J.B.	Skin	6	±	±	++	++	+
	Fascia		+	+	+	o	++
4 D.K.	Skin	7	+	+	o	o	++
	Fascia		+	+	o	o	+++
5 W.R.	Skin	7	+	+	o	o	+++
	Fascia		+	+	±	+	+++
6 L.M.	Skin	9	++	++	o	o	++
	Fascia		++	++	++	o	+++
7 R.G.	Skin	9	++	++	+	+	+++
	Fascia		++	++	++	+++	+++
8 J.M.	Skin	11	±	±	+	o	++
	Fascia		o	o	+++	+	++
9 A.F.	Skin	14	+++	+++	o	o	++
	Fascia		+++	+++	o	o	++
Controls							
10 M.P.	Skin	5	+	+	++	++	±
	Fascia		++	+	+++	o	±
11 D.G.	Skin	7	+	+	o	±	++
	Fascia		++	++	+++	o	+++
12 W.S.	Skin	7	+	+	++	+	+
	Fascia		++	++	+++	o	++
13 I.C.	Skin	10	++	+++	o	o	++
14 W.M.	Fascia	10	++	+++	++	o	+++

Histological data. The biopsy specimens of skin and fascia were divided into two equal parts, half of which were fixed in Zenker's solution and the other half in formalin. Van Gieson's stain, Foot's method of silver impregnation for reticulum, and hematoxylin and eosin stains were employed with the formalin fixed material. Hematoxylin and eosin, Mallory's aniline blue collagen stain, and Weigert's differential stain for fibrin were

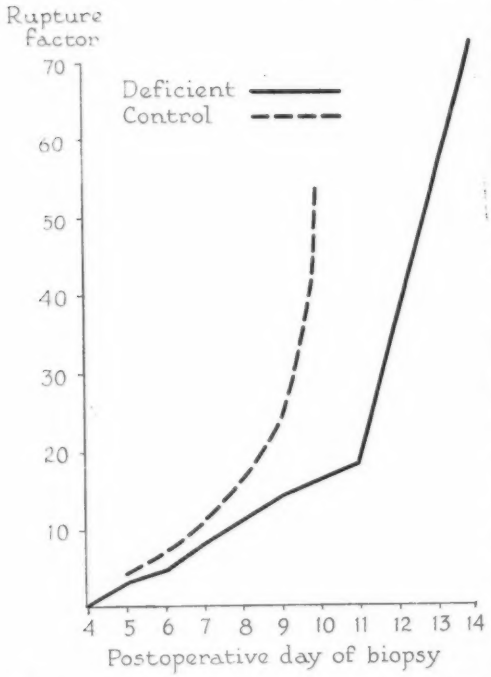

Fig. 19. Comparison of averaged rupture factors of skin of deficient and control groups.

used on the Zenker fixed material. In all, 180 slides were studied. These were graded on an arbitrary scale from o to +++ for each component studied, o being considered a negative amount, ‡ the minimal amount, and +++ the maximum amount in the series. (Numerical values: o; ‡=0.5; +=1; ++= 2; and +++=3.) While admitting the limitation of this method of grading, it offers a means of comparing the slides of the biopsy specimens in relation to each other. This is recorded in Table II.

In all cases, healing in the skin was first evidenced by a proliferation of fibroblasts just beneath the epithelium; while in the fascia, healing generally occurred by a growth of granulation tissue into the wound from the inner and outer surfaces of the fascia.

The reticulum stain was expected to be a more sensitive indicator of interstitial substance in the earlier stages of healing; however this did not prove to be true in all instances. Subject No. 1 (D.A.) showed the presence of collagen after 4 days of healing with no evidence of reticulum. This discrepancy may be the result of taking the section stained for collagen and the section stained for reticulum from separate blocks of tissue. In general, the amount of reticulum paralleled the amount of collagen, slightly more reticulum being evident in the earlier stages of healing and slightly less in the later stages (Fig. 21).

Tensile strength. In comparing the tensile strength with the degree of ascorbic acid deficiency as measured by the saturation tests and tissue depletion determinations, three clear-cut time intervals are available for study. The first is that of the fifth day and is represented by the deficient subject No. 2 (G.H.) and the control subject No. 10 (M.P.). The fifth day was the earliest time period permitting a measurement of tissue strength and is an interval in which the personal or inherent tissue differences of turgor, thickness, and healing propensities may cause variations in results. In addition, the normal momentum of healing is quite slow at this time, and differentiation in healing strength has not had time to develop. Thus it is that these 2 cases present quite similar numerical results and are important only as base lines for comparison and as starting points of the healing curves.

The second interval is that of the seventh day and is represented in the deficiency group by subjects No. 4 (D.K.) and No. 5 (W.R.) and in the control group by subjects No. 11 (D.G.) and No. 12 (W.S.). When an average value of the rupture factors of each group is compared, it is found that there is a definite difference in favor of the control group (Figs. 19 and 20). If one considers that the groups are too small for averaging, then the simple summation of these factors may be an adequate measure for comparison. Thus, the sum of the skin rupture factors for the two deficient subjects is 17.6 as compared with 21.7 for the controls. The sum of the fascia rupture factors for the deficient subjects is 10.6 as compared with 21.2 for the controls. Assuming the normal controls to represent a base line of 100 per cent, calculations reveal that in these deficient subjects the tensile

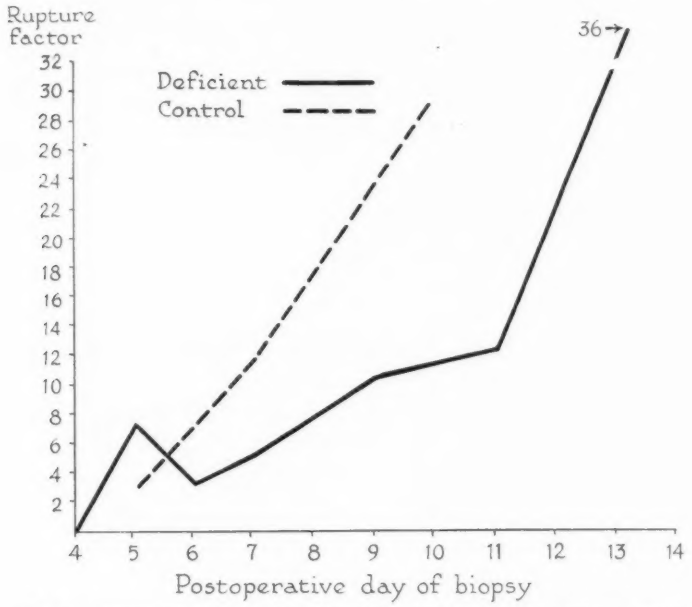

Fig. 20. Comparison of averaged rupture factors of fascia of deficient and control groups.

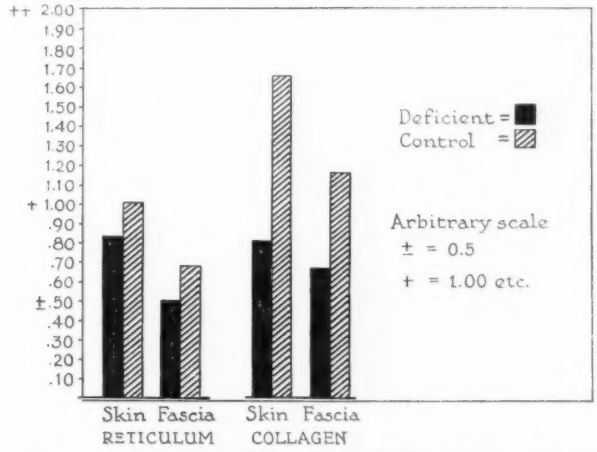

Fig. 21. Averaged value of reticulum and collagen in three control and three deficient subjects with biopsies on fifth and seventh days of healing.

strength of the suture line of the skin and of the fascia was reduced 19 per cent and 50 per cent, respectively. A study of the saturation tests for these subjects reveals that both controls were adequately supplied with ascorbic acid while one of the two deficient subjects (No. 5), previously referred to as having a rupture factor approaching the control aver-

TABLE III

Diet	Subject No. initials	Tissue depletion* milligram ascorbic acid	Saturation test ascorbic acid		Rupture factor		% normal	
			Dose milligram	Secreted into urine in 5 hours milligram	Skin	Fascia	Skin	Fascia
C deficient	4 D.K.	2064	954	6.33	6.95	2.07	80.9	50.0
C deficient	5 W.R.	2323	1021	25.80	10.66	8.54		
Normal control	11 D.G.	(None)	1350†	306.90	14.74	9.22	100.‡	100.‡
Normal control	12 W.S.	(None)	1080†	230 10	7.03	12.00		

*Tissue depletion: This is arbitrarily chosen as the total number of milligrams of ascorbic acid administered (including the saturation test dose) before a blood plasma level of 1 mgm. per 100 c.c. was attained. The rate of administration following the test dose was usually 500 mgm. per day.
†The plasma ascorbic acid levels rose above 1 mgm. per cent upon administration of the saturation test dose of 15 mgm. ascorbic acid per kilogram of body weight. No tissue deficit exists in these control subjects.
‡For purpose of comparison, the control subjects are taken to represent 100 per cent of normal.

age, proved to be less depleted than was suspected. This relative lack of depletion was reflected in a tensile strength higher than a corresponding deficient partner, especially in the fascia, but was not up to the level of the control average. The amount of ascorbic acid spilled into the urine during this subject's saturation test was significantly more than that which was found in the other deficient subjects but yet it was not enough to be compared with any of the control subjects. Thus, it appears that while this subject was quite deficient, he still possessed a minimal amount of vitamin C in his tissues sufficient to obtain adequate healing (Table III).

The third interval is that which approximates the tenth day. The deficient group here consists of subjects No. 6 (L.M.), No. 7 (R.G.), and No. 8 (J.M.), two of these representing the ninth day of healing while the third represents the eleventh day. These can be compared with the ten day control subjects No. 13 (I.C.) and No. 14 (W.M.). The skin wound only was studied in subject No. 13, while only a fascial wound was studied in subject No. 14. The average of the rupture factors for the skin wound of the deficient subjects is 15.3 as compared with 53 for the control subject. The average of the rupture factors for the fascial wound of the deficient subjects is 10.5 as compared with 28.1 for the other control subject. Barring error, due to the use of a single control subject for skin and a single control subject for fascia (though both were consistently comparable) and again assuming the normal controls to represent a base line of 100 per cent, it was found that in these deficient subjects the tensile strength of the suture line of the skin and of the fascia was reduced 71 per cent and 70 per cent, respectively. In other words, the depleted subjects had by this time developed only 30 per cent as much wound holding power as was found in their corresponding normal controls. The tissue depletion studies and the saturation tests on these subjects revealed that enormous amounts of ascorbic acid were needed by the deficient group to attain a fasting plasma level of 1 milligram per cent as compared with that required by the control subjects. These differences are quite evident even when the factor of inflammation in subjects No. 6 and No. 8 is taken into account. This correlation is shown in Table IV.

DISCUSSION

A review of the literature reveals only one instance of clinical scorbutic investigation related to the tensile strength determination of healing human wounds. In 1942, Bartlett, Jones, and Ryan (4) studied the ascorbic acid content of small healing human thigh wounds of 6 supposedly healthy individuals with normal serum proteins who were convalescing from hernioplasties. By using the principle of a direct pull such as we have done, they also measured the tensile strength of the wounds. Five of the 6 subjects showed an adequate

TABLE IV.

Diet	Subject No. initials	Tissue depletion*	Saturation test ascorbic acid		Rupture factor		% normal	
			Dose milligram	Secreted into urine in 5 hours milligram	Skin	Fascia	Skin	Fascia
C deficient	8 J.M.	4200	H	H	18	6.23	29.	
C deficient	7 R.G.	1957	1057	4.44	4	13.33		30.1
C deficient	6 L.M.	5300	H	H	24	11.89		
Normal control	13 I.C.	(none)	900	122.2	53		100.	
Normal Control	14 W.M.	(none)	†	†		28.1		100.

*Tissue depletion: This is arbitrarily chosen as the total number of milligrams of ascorbic acid administered, including the saturation test dose, before a blood plasma level of 1 mgm. ascorbic acid per 100 ml. was attained. The rate of administration, following the test dose, was usually 500 mgm. per day.
H. Subjects marked "H" were hospitalized because of failure of biopsy wound to heal and could not come to laboratory for test.
†Proven normal control subject but no saturation test done at time of experiment.

holding power even though their vitamin C blood levels ranged as low as 0.20 milligram per cent. The sixth individual had a blood level of 0.09 per cent, a tissue ascorbic acid content of 0.0, and a tensile strength determination only one-fifth the average of the other 5 supposed normals. In this depleted subject, a second similar procedure was carried out on the opposite thigh (while the patient was convalescing from the second hernioplasty); an adequate amount of vitamin C then being administered for the next 10 days. The resulting specimen yielded a healing scar whose tensile strength was slightly above the group average while its ascorbic acid content was slightly below average. This isolated instance in the human subject was highly corroborative of the already known guinea pig experimentation correlating the strength of a healing wound with the ascorbic acid content of the tissues.

Our studies on the other hand have been on experimentally produced scorbutics, 9 in all, the other 5 subjects acting as controls. The results as shown graphically reveal the presence of a diminution in healing tensile strength which is more evident before the tenth day than after. In the case of the fascia, this difference approximates 50 per cent but after 11 days there is a development of parallelism such as to suggest development of satisfactory strength by the thirteenth or fourteenth day. The same is true of the skin except that this difference approximates only 30 per cent diminution in strength through the first 8 days and because of the time lag in the deficient subjects, the percentage increases to 60 per cent during the tenth and eleventh days only to show the same tendency to parallelism nearing the thirteenth day. In other words, early in wound healing it was noted that the fascia of the controls had the same wound strength on the seventh day as the deficient subjects on the eleventh while in the skin the comparable days were eighth and eleventh. In the later period, the fascia of the controls achieved on the ninth day the same level of tensile strength as was found in the fascial wound of the deficient subjects on the twelfth day while in the skin the comparable days were tenth and thirteenth. The curves developed by Hartzell and Stone in guinea pigs (using a tensiometer principle for estimation of wound strength) reveal the same differences early in the course of healing, but their parallelism began around the eighth day and was such as to show a marked diminution in wound strength as late as the fourteenth day in the scorbutic animals. Their estimate was about one-quarter normal from the eighth through the fourteenth day, the latter being the termination point of their experiment.

In 1943, Jones, Bartlett, Ryan, and Drummey reverted to guinea pig experiments and

found, while working with ascorbic acid and sulfanilamide, that certain of their results suggested that maximal saturation of the tissues with ascorbic acid aided in providing optimal tissue resistance to infection. Their lowest tensile strength determinations were obtained in animals with scurvy and wound infection. Their mortality figures were highly suggestive that more than a moderate tissue saturation was needed if ascorbic acid was to be of value in increasing tissue resistance. They concluded that complete saturation aided greatly in diminishing infection. This was interesting in the light of Hunt's fine work on the histological aspects of scorbutus. In 1941, he stated that "not only is growth and migration of fibroblasts affected in healing wounds in vitamin C deficiency but phagocytosis is also inhibited."

With this in mind, it is fitting to mention the complications encountered in the deficient subjects while convalescing from the biopsy surgery. As mentioned before, the majority of the subjects underwent an elliptical excision of the suture line followed by a primary closure of the skin edges under a mild degree of tension. This could be considered as wound healing under slightly difficult circumstances. These subjects healed without complication according to the usual gross standards of external evidences of wound healing. Four subjects underwent an excision of the central portion of the wound, this excision being made at right angles in the form of an ellipse and was followed by a primary closure of the new wound. Such a maneuver resulted in a cruciate incision with a moderately severe degree of tension exerted on the healing surfaces. The necessary amount of undermining resulted in some diminution of blood supply to the apex of each skin flap. Circumstances such as these could be construed as poor for healing under normal conditions. All four of the subjects chosen for this latter type of closure were from the deficient group. Three out of the 4 failed to heal by primary intention, as evidenced by their accompanying photographs and case histories. All but 2 subjects received ascorbic acid on the third day following biopsy during the performance of the saturation test, followed by 500 milligrams of ascorbic acid daily until the plasma level attained 1 milligram per cent. The two exceptions were hospitalized because of wound infection appearing on the second day following biopsy, at which time administration of ascorbic acid began. Massive doses of 1000 milligrams daily were administered in some cases after the plasma reached 1 milligram per cent when necrosis was severe, and continued until healing was complete. Final wound healing, therefore, occurred under the influence of administered ascorbic acid.

Subject No. 1. (*D.A.*) A white male, aged 24 years, C deficient, underwent his first skin and fascial incisions on October 17, 1942. The bleeding was so slight that no ligatures were needed in the subcutaneous tissues. Four sutures were placed in the fascia and seven in the skin. He returned to the hospital on the fourth postoperative day for his biopsy. The wound edges were fully intact and sealed throughout. There was no edema, no evidence of subcutaneous bleeding, nor reaction around the sutures. The biopsy was carried out with the procedure which resulted in a cruciate closure. There was a moderate amount of tension on the transverse suture line. His subsequent course was marked on the fifth day following the biopsy by the appearance of a slight amount of skin necrosis in the point of each flap. Occasional sutures were removed and by the seventh day all sutures were out. By the ninth day, the central necrosis had included an area 1.5 centimeters wide and 2.1 centimeters long (Fig. 7). The subject was now placed on large amounts of ascorbic acid for it was felt that the experimental phase of this process was now passed. Eventual secondary healing was completed on the forty-fifth day.

In regard to the biopsy tissue, both the skin and fascial specimens obtained presented excellent apposition of wound edges, but the slightest amount of handling resulted in dissolution at the suture line. The tensile strength of this tissue was too low to permit measurement, but adequate specimens were obtained for histological study.

Subject No. 6. (*L. M.*) A white male, aged 23 years, C deficient, underwent his first skin and fascial incisions on October 17, 1942. There was minimal bleeding experienced so that no ligatures were needed. Four silk sutures were placed in the fascia and seven in the skin. Subsequent healing appeared to be satisfactory, so that every other suture was removed on the fifth day and the remaining on the seventh day. There was a slight amount of redness about the sutures, but the wound was sealed. The edges were entirely intact, and there was no separation. There was no edema or sign of subcutaneous bleeding. The biopsy was performed on the ninth postoperative day at which time the wound appeared quite dry. The procedure used was the type that resulted in a cruciate skin closure. There

was slightly more tension in this instance than in subjects No. 1 and No. 8. The subject left the hospital 24 hours later, but returned in another 24 hours with a temperature of 102.2 degrees F., a white count of 14,000, and a diffuse scarletina-like rash over the trunk of the body. He had experienced chills and fever for the preceding 12 hours. It was recalled that he had a definite chill while on the operating table at the time of his recent biopsy. There was a small amount of serosanguineous drainage from the central portion of the wound, but very little, if any, induration in the periphery. A few sutures were removed, a culture taken, and hot wet dressings were applied. The throat cultures revealed a mixed growth of Staphylococcus albus and nonhemolytic streptococci while that from the wound showed a heavy growth of hemolytic Staphyloccus albus. The temperature peak was 100.8 degrees F. on the following day and reached normal by the fifth day. The subject received a total of 200 cubic centimeters of scarlet fever convalescent serum during the first 2 days of the febrile course as well as an adequate amount of sulfadiazine. One of the clinicians believed that the subject presented a mild form of "strawberry tongue" and later, while in the hospital, a slight scaling of his face and hands was noted. He was placed on a high ascorbic acid supplement to his diet, but wound healing was quite slow. The last sutures were removed on the seventh postoperative day. The central defect measured about 3 centimeters in diameter on the fourth day, but had increased to an area 5 centimeters wide and 6 centimeters long by the eleventh day (Fig. 8).

Subject No. 8. (*J. M.*) A white male, aged 24 years, C deficient, underwent his first skin and fascial incisions on October 17, 1942. No ligatures were needed in the subcutaneous tissues. Four silk sutures were used for the fascia and seven for the skin. The progress of healing was satisfactory so that occasional sutures were removed on the fifth day and the remaining on the seventh. There was no evidence of inflammatory changes about the sutures. The biopsy was performed on the eleventh postoperative day at which time the wound edges were found to be excellently apposed, tightly sealed with no separation. There was no edema or sign of ecchymosis. The procedure used resulted in a cruciate closure with a moderate amount of tension on the transverse incision.

The subsequent course was unusual in that he developed a temperature of 102 degrees F. exactly 24 hours following the closure of the wound. This was also accompanied by some swelling and tenderness about the wound. His white blood cell count was 17,000. Because of the type of culture previously obtained from subject No. 6, it was deemed advisable to remove a few of the central sutures and apply heat to the wound. The temperature peak 24 hours later was 100.6 degrees F., reaching normal the following day. A culture from bloody fluid obtained from the wound at the height of the febrile reaction revealed the presence of a mixed growth of hemolytic streptococcus. A few more sutures were removed on the fourth postoperative day which resulted in more separation of the wound in the transverse axis. At this time, there was no sign of any spreading infection. This subject was fed a diet with ascorbic acid supplement on the second day after the biopsy, but his wound continued to break down so that the granulating surface measured 4 centimeters wide and 7 centimeters long on the ninth postoperative day (Fig. 9). The progress in healing was quite slow, but gradually the granulations appeared healthy enough to accept a split thickness graft on the twenty-seventh day. He left the hospital 11 days later with the graft sufficiently healed to allow walking.

Subject No. 5. (*W. R.*) A white male, aged 25 years, C deficient, underwent his first skin and fascial incisions on October 17, 1942. No ligatures were needed in the subcutaneous tissue. Four silk sutures were placed in the fascia and 7 in the skin. Subsequent healing appeared to be satisfactory so that every other suture was removed on the fourth postoperative day. The biopsy was performed on the seventh day, preceding which the remaining sutures were removed. The wound edges were found nicely approximated and well sealed with no separation. There was no edema, but a slight amount of subcutaneous ecchymosis was noted. There was a slight redness about three of the last sutures removed. The skin biopsy was obtained by using the procedure which resulted in a cruciate closure. There was moderate amount of tension on this second suture line, but the subsequent healing was very good. Every other suture was removed on the fifth postoperative day and the remaining on the seventh day. Photograph in Figure 6 was taken on the thirteenth day following the biopsy.

It is interesting to note that while all of these subjects came from the deficient group, the lone subject who did heal primarily was not as deficient as the others. As a matter of fact, his response to the saturation test was intermediary between the control and deficient group (same subject previously given special mention under discussion of saturation test). Two of the three subjects who failed to heal primarily could be listed as complicated cases because of the obvious infection which developed, but in the light of the above-mentioned work of Bartlett and his associates it would seem logical to assume that the end-results of this poor wound healing and infection might be due to the deficiency status. If this is so it would seem that the vitamin C deficiency state exerts its greatest deterrent influence on tissue healing when circumstances for the latter are poorest, i.e., in the more severe types of wound.

As early as 1923, Höjer reported on the histology of experimental scurvy, stating that the most constant change was an atrophy of the connective tissue fibers in all parts of the body. This study was confirmed by Wolbach and Howe in 1926 and climaxed in 1937 by Mazoué when the latter demonstrated the direct relationship of vitamin C to the production of collagen fibers. This relationship was confirmed by Querido and Gaillard in 1939 while in 1941 Hunt revealed that there might well be found many reticular fibers formed in scorbutic animals, but that these were low in collagen and thus suspected of being poor in strength. Such fibers have been referred to as precollagen fibers which do not mature without vitamin C. Hunt also noted that the proliferating mesodermal cells failed to mature under the same set of circumstances. Animal experimentation concomitant with this extended study further substantiated these microscopic observations and led to the conclusion that the absence of collagen, or mature intercellular cement, results in a wound of poor holding power.

There is no doubt that the guinea pig presents a much more delicate mechanism for presenting the picture of experimental scurvy. It develops severe scurvy in 2 to 3 weeks, whereas many months are necessary to elicit a similar response in man. In the guinea pig there even is a gross difference in the appearance of scorbutic wounds due to the presence of edema along the suture lines with some evidence of mild inflammation plus heavy bloody crusts as late as the eighth and tenth postoperative days. As late as the fourteenth day these wounds are hard and thick as compared to those in the normal guinea pig. Under such circumstances, it is not difficult to diagnose the presence of scurvy with or without the microscope, the essential findings being the edema, pools of unorganized bloody exudate, the presence of some reticular fibers, and the absence of collagen. In the human subjects, our findings in most instances are entirely the same save for the frank edema, but while the deficiency can be noted in the histological section, in some instances it has been difficult to estimate the tensile strength of a particular wound from its microscopic appearance. This is particularly true if the healing time is not considered in evaluating the lack of intercellular cement. Thus, if a suture line presents a total absence of collagen after 10 days of healing, one might forecast a marked diminution in tensile strength, but a comparable situation would not be present after 5 days of healing since the holding power at that time is not so dependent upon the same mechanism. This difficulty is more pronounced where only partial microscopic evidence of the deficiency exists. The explanation for this may vary all the way from the technical difficulties of a two dimensional tissue study to the specificity of ascorbic acid utilization on the part of the individual. Since the completion of our study, this matter has been brought up by Bourne who found that "wounds in scorbutic animals which are receiving different doses of vitamin C may be very similar in general histological appearance but may have very different tensile strength." Despite this relatively minor problem, the overall microscopic picture in this series is entirely in keeping with the findings of other investigators. The slides, for example, of subject No. 8 (J. M.) are outstanding in the series of deficient subjects, showing almost no collagen or reticulum in the fascia (Fig. 10) and a minimal amount next to the epithelium in the skin (Fig. 12) 11 days after the initial incision was made. Fibrocytes were fairly plentiful at the borders of the incision, but none was seen in the central portion of the wound, which was filled with a fibrin clot.

CONCLUSIONS

1. Human subjects on prolonged ascorbic acid depletion exhibit an approximate 50 per cent diminution in tensile strength of healing wounds.

2. Such depletion delays the development of tensile strength in an uncomplicated healing wound from 3 to 5 days up to the fourteenth postoperative day.

3. When circumstances for healing are poor, such as the presence of undue wound tension or diminution in blood supply, this depletion in ascorbic acid is made more evident through gross failure of primary wound healing.

4. The incidence of wound infection under such circumstances suggests the need for ascorbic acid in the tissues for maximum resistance to infection by favoring primary wound healing.

5. Human subjects on prolonged ascorbic acid depletion exhibit a recognizable lack of collagen and reticulum in their healing wounds.

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THE EXCRETION AND CONCENTRATION OF PENICILLIN AND STREPTOMYCIN IN THE ABNORMAL HUMAN BILIARY TRACT: I. GALL BLADDER

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IN recent years penicillin and streptomycin have been subjected to rather extensive clinical and experimental investigation. The excretion of these substances into the normal biliary tract of man has been reported in a few papers (4, 8, 14). Although hope that the antibiotics may prove useful in diseases of the biliary tract has often been expressed, no one has reported any studies on the excretion and concentration of these substances in the abnormal biliary tract of human beings. The present study was undertaken with the specific purpose of determining the rôle that these antibiotics might play in diseases of gall bladders and bile ducts of human beings.

While it must be admitted that it is easier to control observations on the lower animals than on man, it was decided in this study to approach the problem directly by observations on human beings, for, even after animal experiments are concluded, the actual status of the matter in man is still in question. Differences in physiologic processes, both normal and abnormal, in different species of animals are known to exist. Although definite limitations were encountered in an investigation of the type conducted here, the results have given some definite impressions as to the use of penicillin and streptomycin.

REVIEW OF THE LITERATURE

Penicillin in bile. In 1941 Abraham and his associates first reported that penicillin was excreted in the bile of rabbits. It was not until 1943, however, that Rammelkamp and Helm studied excretion of penicillin in bile in man. By introducing a nasal tube into the duodenum of each of 5 normal persons and removing specimens every 15 minutes after intravenous injection of 20,000 units of penicillin, they found that penicillin was present in bile from both the liver and gall bladder. They were able to demonstrate penicillin in bile as early as 15 minutes after injection, and it was present for as long as 2 hours. In 1 case, after a single intravenous injection of 20,000 units, levels in the blood and in bile removed from the common duct by means of an indwelling T tube were determined. They observed, first, that the concentration in the bile exceeded that in the blood, indicating that the liver concentrated the drug; second, whereas no penicillin was demonstrated in the blood after 2 hours, it was still present in hepatic bile up to 2½ hours. Struble and Bellows, while investigating the distribution of penicillin in the eye of the dog after a single massive dose, also noted that the drug was present in bile in high concentration for a long period.

Streptomycin in bile. The reports concerning the activity of streptomycin in bile are limited to 3. Stebbins, Graessle, and Robinson (10) reported that rabbits excreted 8 to 10 per cent of the drug in the bile after 5,000 units per kilogram of weight had been given intravenously. Following a single intravenous injection of 600,000 units in 2 patients, Zintel and his associates found the maximal concentration in bile was attained in 2 hours. In 1 case the level reached 7.5 units per cubic centimeter and in the other, 3 units per cubic centimeter. In each case the concentration in the blood reached more than 30 units per cubic centimeter in 15 minutes, and fell to 18 units in 2 hours. It was interesting to see a lag

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in the appearance of streptomycin in the bile of 1 patient. No activity was present for the first 30 minutes, even though the level in the blood was high at that time. In addition, in neither case did the concentration in the bile exceed that in the blood. Heilman and her associates (4) found 12.5 units per cubic centimeter of the bile and 6 units per cubic centimeter of blood 2 hours after a single subcutaneous injection of 100,000 units of streptomycin, indicating that streptomycin was concentrated in the bile of human beings. When 100,000 units were given subcutaneously every 3 hours for several days, the concentration in the bile on the second and third days was between 3 and 6 units per cubic centimeter.

STUDY OF PENICILLIN AND STREPTOMYCIN IN BILE FROM THE GALL BLADDER

Method. Twenty-five patients who were to undergo cholecystectomy were selected for the study of each antibiotic agent. At periods varying from 12 minutes to 14 hours before operation, each patient was given a single intramuscular injection of either 15,000 units of penicillin or 100,000 units of streptomycin, doses commonly used clinically. No food was given to the patient after the antibiotic agent was administered. The time interval between injection of the antibiotic agent and clamping of the cystic duct at operation was noted. The levels of penicillin or streptomycin in the bile obtained from the gall bladders of these patients were determined in all cases. The level of penicillin was determined by Fleming's modification of the Wright slide cell technique, as described by Heilman and Herrell (5). The organism used for the test was a strain of hemolytic streptococcus. The level of streptomycin was determined by a method similar to the cup-plate method of assay employed by Stebbins and Robinson (11). The organism was a sensitive strain of Staphylococcus aureus. The test plates were placed in the icebox for 20 hours to allow the streptomycin to diffuse from cups, then in an incubator overnight, and the zones of inhibition were read.

A note was made of the report by the roentgenologist of the function of the gall bladder and of the presence and position of stones in the gall bladder and of the condition of the liver and its excretory apparatus at operation.

Results. Penicillin.—In the 25 cases in which penicillin was used three conditions were noted: nonfunctioning gall bladders with stones, functioning gall bladders with stones, and gall bladders without stones. The motor activity of the gall bladder had been determined by the roentgenologist by means of the Graham-Cole test. In the 3 cases in which cholecystectomy was performed and no stones were found, the roentgenogram showed nonfunctioning gall bladders in 2 cases and a functioning gall bladder with stones in the other case.

The results of this study are given in Table I. No penicillin was found in the bile from 5 of the 10 nonfunctioning gall bladders with stones. The time intervals after injection of penicillin in these 5 cases varied from 12 minutes to 12 hours. In these 5 cases a stone was found impacted in the cystic duct at the time of operation, and the gall bladders in 4 of these were reported by the pathologist to be hydropic. The levels of penicillin in the other 5 cases in this group varied from 0.25 unit to 1 unit per cubic centimeter. The cystic ducts in these cases were patent.

In only 3 of the 12 cases of functioning gall bladder with stones was no penicillin recovered. In 2 of these the cystic duct was found to be obstructed at operation. In 1 case the duct was patent, but subsequent study showed that penicillin was not excreted into the hepatic bile in this case. In all of the other 9 cases in this group the cystic duct was patent, the levels varied from 0.06 to 1.9 units per cubic centimeter, and the time intervals after injection of penicillin varied from 45 minutes to 14 hours.

In 3 gall bladders no stones were found. In these the levels of penicillin were 0.24 unit, 1.0 unit and 0.12 unit per cubic centimeter of bile at 45 minutes, 1 hour and 15 minutes, and 10 hours and 45 minutes after injection of penicillin, respectively.

In the entire group in cases in which levels were obtained at long intervals after injection (9 to 14 hours), penicillin was still present in all those in which the cystic duct was patent,

TABLE I.—LEVELS OF PENICILLIN IN BILE FROM GALL BLADDERS FOLLOWING INTRAMUSCULAR INJECTION OF 15,000 UNITS

Condition of gall bladder	Penicillin level, units per c.c.	Time after injection	Obstruction cystic duct
Nonfunctioning with stones	0	12 min.	Yes*
	0	20 min.	Yes
	1.0	1 hr., 45 min.	No
	0	3 hrs.	Yes*†
	0	3 hrs.	Yes*
	0.5	3 hrs.	No
	0.5	4 hrs.	No
	0.5	10 hrs.	No
	0	12 hrs.	Yes*
	0.25	14 hrs.	No
Functioning with stones	0	12 min.	Yes
	0	30 min.	Yes†
	0.25	45 min.	No
	0.96	1 hr.	No
	0‡	2 hrs., 30 min.	No
	1.9	3 hrs., 5 min.	No
	0.5	9 hrs., 30 min.	No
	0.12	11 hrs., 30 min.	No
	0.12	12 hrs.	No
	0.06	12 hrs.	No
	1.0	12 hrs.	No
	0.06	14 hrs.	No
Without stones	0.24	45 min.	No
	1.0	1 hr., 15 min.	No
	0.12	10 hrs., 45 min.	No

*Gall bladder reported by the pathologist to be hydropic.
†Reported by the pathologist that acute cholecystitis was superimposed on chronic cholecystitis.
‡In this case penicillin was not present in bile from the gall bladder, although the cystic duct was patent.

TABLE II.—LEVELS OF STREPTOMYCIN IN BILE FROM GALL BLADDERS FOLLOWING INTRAMUSCULAR INJECTION OF 100,000 UNITS

Condition of gall bladder	Streptomycin level, units per c.c.	Time after injection	Obstruction cystic duct
Nonfunctioning with stones	0	1 hr.	Yes
	1.5	1 hr.	No
	1.6	1 hr., 30 min.	No
	0	3 hrs.	Yes
	0	4 hrs.	Yes*
	0	4 hrs., 15 min.	Yes†
	0	4 hrs., 30 min.	Yes†
	2.0	6 hrs.	No
	0‡	12 hrs.	No
	1.5	12 hrs.	No
Functioning with stones	0	20 min.	No
	0	35 min.	No
	0	40 min.	No
	3.9	1 hr.	No
	0	1 hr., 45 min.	Yes§
	0	2 hrs.	Yes
	1.5	2 hrs., 35 min.	No
	0.8	3 hrs, 10 min.	No
	0.95	4 hrs., 30 min.	No
	0.98	10 hrs.	No
	1.3	12 hrs.	No
	1.5	12 hrs.	No
	0.98	12 hrs.	No
	1.5	12 hrs.	No
Without stones	0‡	2 hrs, 10 min.	No

*Chronic empyema with hydrops.
†Reported by the pathologist that acute cholecystitis was superimposed on chronic cholecystitis.
‡In these cases streptomycin was not present in bile from the gall bladder, although the cystic duct was patent.
§Gall bladder reported by the pathologist to be hydropic.

varying from 0.06 to 1.0 unit per cubic centimeter.

Comment.—Analysis of these results reveals several important facts. In any case in which the cystic duct was obstructed by a stone, no penicillin was demonstrated in the contents of the gall bladder. When the cystic duct was patent, penicillin was usually found in rather high concentration. When these results are compared with those obtained from a subsequent study of excretion of penicillin in hepatic bile (13), it is obvious that, in general, the level of penicillin in bile of gall bladders removed soon after parenteral administration is equal to, or slightly lower than, the highest level which might be expected in the hepatic bile up to that time, and is either equal to, or somewhat higher than, that in the blood. In those cases in which many hours elapsed between administration of penicillin and cholecystectomy, the levels obtained indicated that neither marked concentration, rapid absorption nor ejection of the antibiotic agent from the gall bladder had occurred. In no such case did the level of penicillin exceed 2 units per cubic centimeter. This was true even in cases in which concentration function was excellent, as shown by the Graham-Cole test.

In addition, the darkness of the bile, an index of the ability of the gall bladder to concentrate, did not seem to affect the level of penicillin.

Streptomycin.—Results are given in Table II. There were 10 nonfunctioning gall bladders with stones. Of these, no streptomycin was found in the bile from the gall bladder in 6 cases. In 5 of the 6, the cystic ducts were obstructed completely, and 1 of the 5 gall bladders contained thick creamy pus. In the sixth case, although the cystic duct was patent, no streptomycin was found in the contents of the gall bladder after 12 hours. This patient had active obstructive jaundice, with high levels of serum bilirubin, and it is likely that no antibiotic agent was excreted from the liver (this phenomenon is described more fully in a subsequent report, 13). Streptomycin was recovered from the gall bladders in 4 cases, the levels varying from 1.5 to 2 units per cubic centimeter. The time intervals after injection were from 1 hour to 12 hours. The cystic ducts in these 4 cases were patent.

In the 14 cases of functioning gall bladders with stones, no streptomycin activity was found in 5. However, the time intervals after injection in 3 were less than 1 hour, and subsequent study showed that there often was a lag of a half hour or more in the appearance of streptomycin in hepatic bile (13). In the other 2 cases in which no streptomycin was found in the bile from the gall bladder, the cystic duct was obstructed, and in 1 of these the gall bladder was hydropic. In the remaining 9 cases the level of streptomycin varied from 0.8 to 3.9 units per cubic centimeter of bile, and the time intervals after injection varied from 1 hour to 12 hours. The cystic ducts in these 9 cases were patent.

One gall bladder contained no stones. However, no streptomycin was demonstrated 2 hours and 10 minutes after injection. Further study revealed that this patient had marked impairment of hepatic function, as shown by the hippuric acid excretion test, and also an elevated level of serum bilirubin.

In all cases of gall bladders in which levels were obtained after long intervals (10 to 12 hours), streptomycin was still present in all those in which the cystic duct was patent, the highest level being 1.5 units, the lowest, 0.98 unit per cubic centimeter of bile.

Analysis of these results leads to the same conclusions as were reached when penicillin was used.

COMMENT

Any substance given parenterally may reach the lumen of the gall bladder by one of two routes: either through the bile or by way of the blood vessels in the wall of the gall bladder. It is known that the gall bladder fills passively when the pressure in the common duct reaches a critical level of 50 to 70 millimeters of water. Therefore, if the antibiotic agent reaches the bile in the gall bladder through the biliary tree, when the cystic duct is patent the level of the antibiotic agent obtained in the bile of the gall bladder should be either equal to the highest level in the hepatic bile up to that time, or somewhat lower than this highest level as a result of dilution in the gall bladder which may already have contained bile before the excretion of antibiotic agent from the liver started.

If, on the other hand, the agent does not reach the lumen of the gall bladder through the biliary tree, it may be supposed that it does so through vessels in the wall of the gall bladder. That this does not occur is proved by the results of the present study.

From this investigation it appears that the major factor concerned in the presence of penicillin or streptomycin in the bile of the gall bladder is the patency of the cystic duct. Lynn and his co-workers came to a similar conclusion while studying excretion of sulfonamides in dogs in which the cystic ducts were experimentally obstructed. In all of the cases in the present study in which the duct was obstructed completely by a stone, the antibiotic agent was not recovered from the contents of the gall bladder.

This is a significant observation since in most cases of acute cholecystitis and empyema obstruction of the cystic duct is also present (2, 3, 6, 9). When these conditions coexist penicillin or streptomycin is almost certain not to get into the lumen of the infected gall bladder. Although antibiotic agents do reach the tissues of the gall bladder through the

blood stream, and conceivably may help control infection in the wall, it is unlikely that these agents will overcome the infection present in the bile in the lumen. While it is true that, in the main, the cases in this study were examples of chronic disease of the gall bladder, the fact that in 4 cases reported by the pathologist to be acute cholecystitis superimposed on chronic cholecystitis the antibiotic agent was not found in the bile at least suggests that acute inflammation does not alter the mode of entrance.

In chronic cholecystitis with stones, the effectiveness of penicillin or streptomycin in sterilization of the contents of the gall bladder in any given case cannot be predetermined, because in only some of the cases of this type does the drug reach the bile of the gall bladder. The cystic duct of a gall bladder with stones may become obstructed at any time. However, once the antibiotic agent has entered the lumen, it remains there for many hours in fairly high concentration, since it is neither rapidly absorbed nor ejected from the gall bladder.

SUMMARY AND CONCLUSIONS

After intramuscular injection of 15,000 units of penicillin or 100,000 units of streptomycin, no antibiotic agent was found in the bile of gall bladders in cases in which the cystic duct was obstructed. Antibiotic agent was found in large amounts in gall bladders in which the cystic duct was patent, provided that the antibiotic agent was excreted normally from the liver.

The roentgenologic report was of little value in indicating from which gall bladders the antibiotic agent would be recovered.

The antibiotic agent was neither highly concentrated nor rapidly absorbed nor ejected from the lumen of the gall bladder.

Penicillin and streptomycin may prove of no value in acute obstructive cholecystitis.

The usefulness of penicillin or streptomycin in any given case of chronic cholecystitis with stones is uncertain.

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TOTAL GASTRECTOMY FOR CARCINOMA OF THE STOMACH

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IN the period from July 1, 1944, to December 1, 1945, a series of 25 patients with carcinoma of the stomach were operated upon. In 20 of these cases, total gastrectomy was performed with 2 immediate deaths, an operability rate of 80 per cent, and an operative mortality rate of 10 per cent.[1] Seven patients have now survived for over a year, have resumed a part of their previous occupations, and with a special dietary and medical regimen show little clinical evidence of digestive or metabolic disturbance.

In the present series all the neoplasms were at least moderately extensive, and some had invaded the entire stomach. These results, however, together with the recent successful reports of Horsley, Farris, Ransom, and Coller, Jones and Kehm, and others have led to the belief that the operability rate and the percentage of 5 year cures following the surgical treatment of malignant gastric neoplasms would be increased if total gastrectomy were more frequently employed even in the treatment of the smaller early lesions of the pylorus and fundus. All of the neoplasms encountered in the present series originated in the pyloric or fundic portion of the stomach. Tumors of the cardia, although sometimes successfully treated by total gastrectomy, have characteristic metastatic pathways which present special surgical problems. Treatment of lesions of the cardia of the stomach is not included in the present discussion.

DISCUSSION

The careful study of the regional lymphatic metastases of carcinoma of the stomach made by Coller, Kay, and MacIntyre lends strong support to the more frequent use of total gastrectomy. These authors found it impossible to tell without microscopic section whether lymph nodes were invaded by metastases unless they were definitely replaced by carcinoma. There were metastases to regional lymph nodes in 75.5 per cent of the cases they studied. The upper margin of the neoplasm in the wall of the stomach could not be determined by palpation alone at the time of operation in 24.5 per cent of the cases. There was no relation between the duration of symptoms or the size of the neoplasm and lymphatic metastasis. The authors conclude that whether palpable lymph nodes are or are not present, the regional lymph nodes should be included within the resection to increase the likelihood of cure.

The chances of complete eradication of a malignant tumor would certainly be greater with block excision of the entire stomach and regional lymph nodes than with local excision of the growth or subtotal resection of the stomach. Just as radical mastectomy and abdominoperineal resection of the rectum are preferred in the treatment of malignant lesions of the breast and the rectum respectively, so total gastrectomy, I believe, should be the procedure of choice in many cases of malignant gastric tumor which at the present time are routinely treated by subtotal resection. The more widespread use of such a procedure is dependent upon the development of a technique which lowers the operative mortality and postoperative complications to compare more favorably with those of other types of gastric resection, and upon evidence that the human body can adapt itself to the absence of a stomach and maintain a satisfactory nutritional state.

Reports from various clinics indicate that the operative mortality following total gastrectomy is declining. Jones and Kehm have

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[1]One other successful total gastrectomy not included in this series was performed on a patient with a large benign gastric ulcer. At operation the lesion was thought to be a neoplasm. Since that time the diagnosis of malignancy has been established by routine microscopic section before continuing the operation. Thus the operative mortality for all 21 total gastrectomies is just under 10 per cen

recently reported 8 consecutive cases without a death. Farris, Ransom, and Coller in 1943 had only 2 deaths in 19 cases, one of a patient 79 years old. In 1943 Horsley reported 3 total gastrectomies without a death. These series, although small, indicate that the mortality rate of total gastrectomy is being lowered to compare more favorably with that following other types of gastric resection for malignancy.

As regards the adaptation of the gastrointestinal system to the absence of a stomach over a period of years our knowledge is limited, for in the past, total gastrectomy has been reserved for such advanced malignant disease that most of the patients have died within a few months. In all, 16 patients (10) are known to have survived for over 3 years, and all of these patients were able to lead an active life with few dietary restrictions. Farris, Ransom, and Coller studied the digestive function of 4 patients who had survived total gastrectomy for over 4 years. They found no evidence of disturbance in the digestion of fats and proteins. The absorption of glucose was more rapid than normal. The chief disturbance noted was in the metabolism of iron. In the absence of hydrochloric acid from the stomach the ferric and organic iron in the diet were not absorbed, and hypochromic microcytic anemia developed unless the patients were given ferrous iron regularly. On the other hand, Rekers, Pack, and Rhoads found in 3 patients 6 months after the performance of total gastrectomy, impaired ability to digest or absorb the fat of the diet, and 1 patient had impaired ability to digest or absorb the protein of the diet. Their patients had normochromic normocyctic anemia. According to Pack and McNeer, of 80 patients who have survived total gastrectomy, 82.5 per cent subsequently died of metastasis. In the remainder of the group there were 4 cases which suggested that the interference with nutrition following total gastrectomy had been severe enough to cause death. Two of these patients died of anemia, 1 of general weakness, and 1 of acute enteritis.

In summarizing this point there are three important considerations: (1) Sixteen patients are known to have led a fairly normal life for more than 3 years after total gastrectomy. (2) A few patients have apparently been unable to adjust the digestive apparatus to the absence of a stomach and in some instances death has ensued as a direct result. It is possible that these patients might have survived if more detailed and prolonged postoperative care had been instituted. (3) The majority of the patients have died of metastasis before follow-up studies could be made. The final answer must await further clinical experience and study. The present series gives some additional information regarding this phase of the problem.

CASE MATERIAL

All of the patients in this series were seen in consultation with Dr. Alfred Blalock, Professor of Surgery and Director of the Department of Surgery in the Johns Hopkins Hospital. In using the term "total gastrectomy" the criterion of Finney and Rienhoff has been followed; that is, removal of the entire stomach including the pyloric and cardiac sphincters.

In this series there were 15 male patients and 5 female patients. The ages ranged from 37 to 76 years; all but 4 were over 55. Although in some instances it was very difficult to tell exactly when the symptoms due to the carcinoma began, the duration of symptoms ranged from 1½ months to 11 months. Four patients had had similar symptoms for many years which had been attributed to peptic ulcer. In 2 patients a scarred duodenal ulcer was found in addition to the gastric carcinoma. In 2 instances it was definitely established that the neoplasm originated in a large chronic gastric ulcer. With the exception of one whose weight had remained unchanged, all of the patients had lost from 15 to 20 pounds in weight.

On admission to the hospital the hemoglobin content of the blood of these patients ranged from 5.0 to 15.6 grams, with an average value of 11 grams. In 14 patients determinations of the blood chemistry were made. The total serum protein was below normal in only 2 patients. There was a slight decrease in the blood chlorides in 4 patients. Seven patients had no free acid in a fasting specimen

TABLE I.—PORTION OF STOMACH WALL INVADED

Name	Portion of stomach invaded	Metastasis to regional lymph nodes	Distant metastasis	Direct extension
F.B.	Distal one-half	o	o	Anterior abdominal wall. Transverse mesocolon. Pancreas
J.S.	Distal one-half	+	o	Mesocolon
D.B.	Distal one-third	+	o	o
J.W.	Entire lesser curvature	o	o	o
J.P.	About periphery of chronic gastric ulcer	+	o	o
G.B.	Pyloric antrum and posterior wall	o	o	Pancreas
W.T.	Pyloric antrum	+	o	Transverse mesocolon
S.T.	Entire lesser curvature and two-thirds of stomach wall	+	o	Esophagus
N.M.	Distal one-half	+	o	o
E.W.	Entire lesser curvature	+	o	Duodenum
J.N.	Pyloric antrum	+	o	Duodenum
J.B.	Pyloric antrum	+	o	o
C.H.	Distal one-half	+		Duodenum. Anterior abdominal wall
E.G.	Entire stomach wall	+	Celiac lymph nodes (?)	Pancreas
T.H.	Pyloric antrum	+	Celiac lymph nodes (?)	o
G.P.	Entire lesser curvature and posterior wall	+	o	Pancreas
J.L.	Entire lesser curvature and one-half of stomach wall	+	o	o
F.C.	Entire stomach	+	o	Mesocolon
A.H.	Distal one-third	+	o	o
J.B.	Distal one-half	+	o	o

of gastric juice; in the others the free acidity ranged from 8 to 48 degrees. Roentgen and fluoroscopic examinations were made of the stomach after the ingestion of barium in 16 patients. The presence of a neoplasm was correctly diagnosed in all but 1. In this patient the presence of an ulcerative lesion was noted in the report, but it was not stated that this was due to neoplasm. The changes in the contour of the stomach noted upon roentgen examination agreed closely with the extent of the gross lesion of the stomach found at operation.

As regards the general medical condition of the patients before operation, it was found that 1 patient had rheumatic heart disease with mitral and aortic insufficiency, hypertension, and cardiac hypertrophy. Six other patients had advanced arteriosclerosis, one with a history of angina pectoris and another with hypertension. The serologic test for syphilis was positive in 4 patients although there were no clinical signs of the disease. One patient had an extensive fibroid infiltration throughout both lungs which was thought to be due to inactive tuberculosis. One patient had mild diabetes mellitus with a blood sugar determination of 131 milligrams per cent.

The following classification groups the cases according to the approximate portion of the stomach wall invaded by the tumor (Table I). The entire stomach wall was invaded in 3 instances. In 5 patients the growth extended throughout the length of the lesser curvature. The distal half of the stomach wall was infiltrated in 5 patients, and the distal one-third in 2. The lesion was restricted to the pyloric antrum in 4 instances. One patient had a large chronic gastric ulcer with malignant changes about the periphery. Three patients showed no evidence of extension to the regional lymph nodes. There was 1 patient with involvement of the lymph nodes of the lesser curvature, 1 with involvement of the lymph nodes of the greater curvature, and 1 with involvement of the lymph

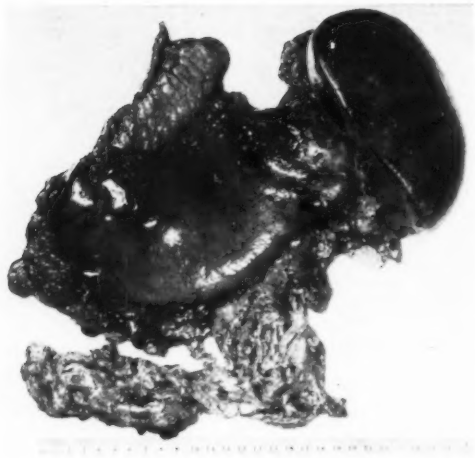

Fig. 1. G.B. Operative specimen. Entire stomach, omentum, spleen, and distal three-fourths of pancreas.

nodes along both curvatures. In 9 patients there was extension to the lymph nodes about the pylorus, along the lesser curvature, and about the left gastric artery. Lymph nodes about the pylorus, along both curvatures, and about the left gastric artery were invaded in 5 cases.

The spleen was removed with the stomach in 7 patients. In 4 patients there was direct extension of the growth into the body of the pancreas, and in 2 of these patients it was necessary to remove three-fourths of the pancreas and the spleen together with the stomach[1] (Fig. 1). A portion of the peritoneum overlying the middle colic vessels in the transverse mesocolon was removed in one case in which there was direct extension of the carcinoma into this area. The growth had extended into the duodenum in 3 patients and into the esophagus in one.

During this same period an exploratory operation was performed upon 5 other patients who had carcinoma of the stomach with generalized carcinomatosis. In 2 a posterior gastroenterostomy was performed. Thus of 25 patients with carcinoma of the stomach operated upon during this period, total gastrectomy was performed in 20, or 80 per cent.

[1]In one of these patients surgical diabetes developed after operation, the blood sugar rising to 297 milligrams per cent on the 11th postoperative day. At that time 15 units of protamine zinc insulin a day were required for regulation. During the next week the blood sugar slowly declined to normal and remained so. At the time of discharge on the 31st postoperative day there was no sugar in the urine. The blood sugar was 102 milligrams per cent, and the patient was taking 10 units of protamine zinc insulin a day. Although the extent of the pancreatic excision was the same in the second patient, the determinations of his blood sugar were normal throughout his postoperative course.

OPERATIVE TECHNIQUE

The operative technique is as follows: The abdomen is entered through an upper midline incision which extends from the apex of the left xiphocostal notch to the umbilicus. A specimen for examination by frozen section is taken of the original lesion or of a grossly involved regional lymph node. The extent of the lesion is determined. The liver, the cul-de-sac, and the regional, mesenteric, and aortic lymph nodes are palpated. If resection is decided upon, the omentum is freed from the transverse colon and removed with the stomach. The right gastric and gastroepiploic arteries are divided as close to their origins as possible and the duodenum is freed down to the head of the pancreas and divided. The stomach is freed posteriorly. If there is evidence of peritoneal implants or extension of the tumor, the peritoneum of the posterior wall of the lesser peritoneal sac is removed. When difficulty is encountered in visualizing the vasa brevia, the spleen is mobilized laterally by freeing its peritoneal attachments. If bleeding is troublesome in this region or if extension to the splenic lymph nodes is suspected, the main splenic vessels are divided and the spleen is removed with the stomach. With the greater curvature mobilized, the stomach is reflected upward and to the left, a maneuver which brings the left gastric vessels clearly into view. The left gastric vein is traced down to the splenic vein and divided. The left gastric artery is ligated at the celiac axis and all lymph nodes in the region are removed.

At this point a peritoneal flap is raised which starts from the gastrohepatic omentum and extends across the esophagogastric junction to the left side of the diaphragm. This flap is elevated and the vagus nerve on each side of the esophagus is divided. This procedure allows the abdominal esophagus to stretch and the cardia of the stomach to drop down several centimeters. Only enough of the areolar tissue is divided to allow clear

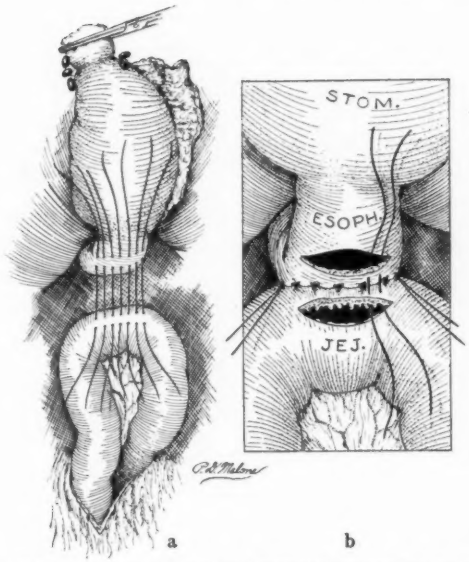

Fig. 2. a, Stomach freed and retracted over upper angle of incision. Posterior row of interrupted silk sutures placed between jejunal loop and posterior wall of esophagus. b, Opening made into lumen of esophagus and jejunum. Second posterior row consists of interrupted catgut sutures which pass through the entire thickness of the wall of esophagus and jejunum.

identification of the wall of the esophagus. No attempt is made to free the esophagus up through the diaphragm.

Both an antecolic and a retrocolic esophagojejunostomy have been performed; now, however, the retrocolic type is generally employed. The chief advantage of this type is that at times the jejunal mesentery is short and difficulty is encountered in getting the jejunum up to the esophagus. Placing of the jejunum anterior to the colon causes further shortening of the mesentery. When the retrocolic method is followed the transverse mesocolon is sutured across the intestine obliquely as recommended by Morton. In 3 of the cases in this series it has been necessary to divide one of the primary mesenteric arteries to the jejunal loop to afford sufficient length for the anastomosis. One row of interrupted silk sutures is placed between the posterior wall of the esophagus and the jejunum and the sutures are tied (Fig. 2a). The posterior wall of the esophagus is divided and a corresponding opening is made in the jejunum. The second row of sutures is formed of interrupted catgut sutures which pass through the entire wall of the esophagus and jejunum and carefully approximate the mucosal edges (Fig. 2b). The anterior wall of the esophagus is divided and the two rows of sutures unite the anterior edges in similar fashion. The peritoneal flap previously formed is now sutured over the anastomosis to the jejunum (Fig. 3). This step helps to support the jejunal loop as well as to reinforce the suture line.

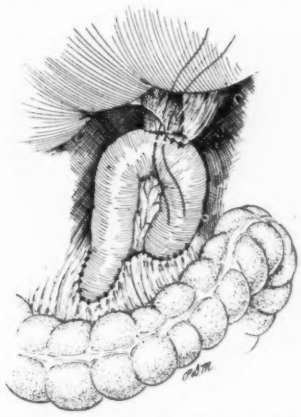

Fig. 3. Esophagojejunal anastomosis completed. Peritoneal flap sutured to jejunum. Transverse mesocolon sutured obliquely across jejunal loop.

The procedure as outlined is a combination of certain features of several different methods previously described by others. There are, however, points which should be emphasized as being particularly important. In an attempt to reduce the magnitude of the operation, all of the steps that are not essential have been eliminated. Enteroenterostomy, recommended by most operators, is usually unnecessary and has not been used. An enterostomy for feeding the patient after operation is unnecessary if the patient is properly prepared before operation and modern intravenous therapy is used after operation. Numerous other steps such as duodenojejunostomy and complicated esophagojejunal anastomoses have been omitted. A simple upper midline incision gives ample exposure and is quickly opened and closed with mini-

mal loss of blood. The duodenum should be divided as close to the head of the pancreas as possible. This permits complete removal of all pyloric lymph nodes and is an additional safeguard in those cases in which there is extension of the gastric carcinoma into the duodenum. Three such cases were encountered in the present series.

With the stomach well mobilized and elevated out of the wound, the left gastric vessels are clearly visualized. They are divided at the celiac axis and all surrounding lymph nodes removed. As this region is a pathway of early dissemination by the lymph nodes, this step is important. The esophagus is mobilized and exposed just enough so that its walls are clearly defined. Every effort is made to preserve its blood supply. The diaphragmatic and mediastinal esophagus are not disturbed unless extension of the growth into the abdominal esophagus necessitates this step. The abdominal esophagus is surrounded by fibrous areolar tissue which if left intact holds sutures better than the bare muscle of the mediastinal esophagus.

There have been no signs of stricture formation at the site of anastomosis in any of these cases. The use of interrupted sutures throughout the anastomosis is important in preventing this complication. Great care is used in placing all of these sutures; although this care is tedious at times, the rewards are great. Forty per cent of the reported operative deaths following total gastrectomy have been due to leakage from the line of anastomosis (10).

POSTOPERATIVE COURSE

In this series of 20 cases there were 2 immediate deaths. In 1 patient who died an attempt was made to form a food reservoir from the loop of jejunum that was anastomosed to the esophagus. The blood supply of a portion of the jejunum adjacent to the esophagus was impaired by the procedure. Gangrene developed in this area with perforation on the 10th postoperative day and the patient died of generalized peritonitis.[1] The second operative death occurred in a 43 year old colored female who had a mild diabetes mellitus. Total gastrectomy was performed on October 23, 1945, for an extensive carcinoma which involved the distal third of the stomach with metastasis to the regional lymph nodes. Twenty-four hours after operation the patient's temperature rose to 105 degrees and signs of pneumonia appeared in the left lung. In spite of the administration of penicillin and sulfamerazine her condition grew steadily worse. Forty-eight hours after operation pulmonary edema developed and she died a short time later. Of the other immediate complications only one has been serious. In this patient acute pancreatitis developed on the second postoperative day, which slowly subsided with conservative treatment; however, as soon as oral feedings were started he showed signs of partial high intestinal obstruction, and a second exploration was performed on the 18th postoperative day. It was found that a loop of upper jejunum was bound to the lateral peritoneal wall by adhesions in the left upper quadrant, causing intestinal obstruction. The adhesions were released. The remainder of the patient's postoperative course was uneventful. In 2 patients venous thrombosis developed in a lower extremity which was treated by ligation of the femoral vein. There was 1 case of postoperative atelectasis which responded quickly to intratracheal aspiration and the administration of penicillin. There have been no difficulties with the line of anastomosis; there have been no fistulas, intra-abdominal abscesses, or strictures. The average postoperative stay in the hospital for these patients has been 25 days.

The adjustment of the alimentary tract to the absence of the stomach has been remarkable. The patients have been given water in small amounts by mouth on the 4th postoperative day. The amount has been increased gradually and other liquids have been added. By the 10th postoperative day almost all of the patients have been able to take a soft diet divided into 6 small feedings. After starting to eat solid food 5 of the patients complained of heartburn and 9 of a feeling of abdominal fullness after eating. The heartburn responded quickly to small doses of amphojel. The feeling of fullness was more troublesome. This symptom has been at-

[1]Two cases in which this method was successfully used were later reported by Engel.

tributed to the limited capacity of the jejunum, and the patients were given frequent small feedings. In some of these patients this discomfort has continued for months after operation. Two patients have had transient diarrhea during the second postoperative week which subsided spontaneously. One to 3 soft formed stools a day is the usual bowel habit for these patients.

Roentgenograms taken at the time of discharge showed 2 instances in which there was slight delay in the passage of barium from the esophagus into the jejunum. Both of these patients were asymptomatic, however. In another patient the barium passed into the proximal loop, which was dilated. In none of the patients was there any retention of the barium in the proximal loop after 5 hours. De Amesti has reported an instance of great dilatation and retention in the proximal loop in a patient without an enteroenterostomy between the afferent and efferent loops, and he stresses the importance of performing such an anastomosis. It is my opinion, however, that if the esophagojejunal anastomosis heals without undue scarring or stricture formation, there is no delay in the emptying of the proximal loop. Four of these patients have complained of occasional regurgitation of small amounts of bile stained fluid as long as 2 months after operation. Thus far, however, this regurgitation has not been sufficiently frequent or severe to warrant the performance of an enteroenterostomy as a routine part of the operative procedure. The barium passed through the small intestine more slowly than normal in 2 patients, and in another there was delay in the ileum suggestive of partial obstruction. This patient's progress while in the hospital was rather slow and he vomited small amounts on a number of occasions. Since discharge, however, he has improved. He has gained weight and has returned to work.

With the exception of a slight decrease in blood chlorides in 6 patients, all blood chemistry values were within normal limits at the time of discharge. These included nonprotein nitrogen, carbon dioxide combining power, chlorides, total proteins, albumin, and globulin. The hemoglobin content of the blood at the time of discharge ranged from 10.8 to 14.9 grams with an average of 12.4 grams for the group.

TABLE II.—CAUSE OF DEATH

Name	Survival period	Cause of death
E.W.	2 weeks	Slough at site of gastric pouch
A.H.	2 days	Pneumonia cardiac failure
J.B.	3 months	Recurrence
J.N.	3 weeks	Inanition
C.H.	3 months	Recurrence
T.H.	2 months	Recurrence
P.L.	2 months	Recurrence
E.G.	2 months	Recurrence
F.B.	5 months	Inanition
G.P.	7½ months	Recurrence

FOLLOW-UP STUDIES

Tables II and III summarize the condition of these patients at the time of this report. It has been 1 year and 7 months since the first operation. The last gastrectomy in this series was performed 4 months ago. Ten of the patients who were submitted to total gastrectomy have died. In addition to the 2 operative deaths described, 6 patients have died of recurrence of the carcinoma. It is not surprising if we bear in mind the extent of their lesions, that 5 of the patients have died of recurrence within 3 months after operation. On the other hand, some of the patients with the longest survival periods have had even greater involvement of both stomach and regional lymph nodes than those who have died so soon of recurrence.

In this limited series with the relatively short time that has elapsed since operation, no correlation can be made between the size and type of the lesion or of the regional lymph node invasion and the survival time. In none of the cases was total resection attempted if distant metastasis was thought to be present at the time of operation. Two of the patients with rapid recurrence of the carcinoma showed extensive metastatic implants over the visceral and parietal peritoneum at the time of death, and it might be suspected that operative trauma was directly responsible for this extensive "seeding" of the peritoneal cavity. In 2 other patients with recurrence.

TABLE III.—PRESENT CONDITION OF SURVIVORS

Name	Postoperative interval	Weight	Appetite	Food capacity	Gastrointestinal symptoms	Stools	Work
J.W.	19 months	Gaining slowly, 10 lbs. under best weight	Good	Must eat small meals	Occasional burning and fullness after meals	Normal 1xD	Regular
N.M.	19 months	Gained 10 lbs. after operation. No change in last 4 months	Good	Slightly less than regular meals	None	1-2xD Normal	Light housework
J.P.	14 months	Gained 2 lbs. since operation	Good	Eats 6 small meals daily	Occasional epigastric pain. Fullness if he eats too much	Normal 1xD	Regular
W.T.	13 months	Gained 10 lbs. after operation. No change in last 8 months	Good	Eats 4 to 6 meals a day	Occasional fullness after meals	1-2xD Normal	Regular
S.T.	13 months	Gained 5 lbs. since operation	Good	Normal	Occasional difficulty swallowing liquids	Constipated at times 1xD	Housework
G.B.	13 months	Gained 5 lbs. since operation	Good	Normal	None	2xD Normal	Regular light work
D.B.	12 months	Gained 12 lbs. since operation	Fair	Must eat small meals	Burning, fullness and eructation after eating	Normal 2xD	Irregular light work
J.S.	8 months	Gained 5 lbs. since operation	Fair	Must eat small meals	Fullness and burning after meals	Normal 1-2xD	Unable to work
J.B.	4 months	Slight gain	Fair	Eats 6 meals a day	Fullness after meals	2xD Normal	3 hours daily light work
F.C.	4 months	Gained 10 lbs.	Fair	Eats 6 meals a day	Occasional regurgitation	2xD Normal	Unable to work

one of whom survived 7½ months, large retroperitoneal masses developed along the aorta, suggesting that the malignant condition had spread to unsuspected lymph nodes beyond the limits of the resection at the time of operation.

The remaining 2 patients who have succumbed apparently died of inanition. They illustrate one of the problems in the postoperative management of gastrectomized patients. J. N., a 55 year old colored male, underwent total gastrectomy on December 16, 1944, for an extensive carcinoma of the lesser curvature of the stomach with invasion of regional lymph nodes. No distant metastases were found. Two days after operation, atelectasis of the left lower lung field developed, but he recovered quickly in the next 24 hours. Thereafter his course was uneventful. He was started on liquids by mouth on the 4th postoperative day. He tolerated his feedings well and his diet was steadily increased. At the time of discharge from the hospital on the 16th day after operation, he was eating a full soft diet taken in 6 small feedings a day. He had been up and walking about the ward for 5 days and had no complaints. Roentgenography after the ingestion of barium showed the esophagojejunal anastomosis to function satisfactorily. He was discharged in the care of friends who apparently had no regard for his dietary requirements. Eight days later he was returned to the hospital in a comatose condition and died within a few hours. He was said to have taken nothing by mouth after discharge but small sips of water. At autopsy the anastomosis was found to be widely patent. Scattered microscopic metastases were found in other organs, but there was nothing to explain his early death but starvation and dehydration.

F. B., a 60 year old colored man, was operated upon on August 17, 1945. Total gastrectomy was performed for an extensive carcinoma which involved the distal one-third of the stomach with metastasis to regional lymph nodes and extension into the posterior surface of the anterior abdominal wall. His postoperative course was complicated by an attack of acute pancreatitis during which the serum analysis showed 9.9 milligrams per cent reducing substance per milliliter or 540 per cent of average normal (9). He recovered from this attack spontaneously but later partial intestinal obstruction developed. Exploratory laparotomy was performed on the 23d postoperative day when adhesions about a partially obstructed loop of jejunum were freed. Following the second operation his course was uneventful, and at the time of discharge on September 30, 1945, he was taking a full soft diet divided into 6 small feedings a day. His weight was increasing. He was followed thereafter at weekly intervals by Dr. Moses Paulson in the medical outpatient department. His weight increased, his appetite was good, and he followed instructions fairly well. His only complaint was of intermittent edema of the ankles. The total serum protein on November 1, 1945, was 6.63 grams per cent. The nonprotein nitrogen was 30 milligrams per cent and serum bilirubin was less than 0.8 milligram per cent. Jejunoscopy on December 12 was essentially negative. He was last seen in the outpatient department on January 11, 1946. Six days later he was brought to the accident room to be pronounced dead; how-

ever, a faint cardiac pulsation was heard and intensive supportive therapy was instituted. He improved for a time but died in 24 hours. Permission for autopsy was not granted.

The patient had no relatives and a reliable history of events leading up to this final episode could not be obtained. He had apparently been feeling weak for several days. About 3 days before admission he had fallen without suffering any particular injury, but following this accident he stayed in bed. As there was no one to care for him he had eaten practically nothing. His condition grew steadily worse up until the time he was admitted to the hospital. Before therapy was instituted his blood sugar was 20 milligrams and the nonprotein nitrogen 58 milligrams per cent. Five minutes after receiving 50 cubic centimeters of 50 per cent glucose intravenously he responded to verbal stimuli for the first time. It was our belief that the patient died of starvation and dehydration.

The terminal events in these 2 cases were very similar. It was felt that both of these patients would have survived had they been provided with ordinary dietary requirements. During a period of a very few days they had declined from a relatively good general state of health into a moribund condition that failed to respond to intensive therapy. The nutritional reserve of these patients is apparently so small that the absence of an adequate food intake for a short time cannot be tolerated. It is imperative that these patients be seen frequently after operation and any disturbance in nutritional intake be reported immediately. We have recently adopted the rule that unless we can be certain that the care of these patients after returning home will be entirely satisfactory, they must remain in the hospital for an extra week beyond the usual discharge date to allow them to gain additional strength. The management of these patients after discharge from the hospital has been supervised by Dr. Moses Paulson. The details of the medical and dietary regimen which he has developed, together with the observations made by jejunoscopy, will appear in a subsequent publication.

The survival period of the 10 patients alive at the time of this report ranges from 19 months to 4 months. All of these patients have gained weight although the increase has usually not been great. The weight of none of these patients has equalled his normal weight before the onset of gastric symptoms. The lack of adequate gain in weight has been rather puzzling for all of the patients have a good appetite and apparently eat well. Careful questioning, however, has disclosed the fact that even after a year and a half, the usual meal is smaller than normal. Too large a meal brings on an uncomfortable feeling of epigastric fullness and hence they limit their intake. "Between meal" nourishment, which is advised, has frequently been omitted, particularly after the patients return to work. New diets are being tried at present. Another important factor is the large amount of unabsorbed fat which is excreted in the stool. Recent preliminary metabolic studies in 3 of these cases, 7 months or more after operation, conducted by Dr. John E. Howard and Mr. Lay Fox, confirm the results of Rekers, Pack, and Rhoads of an impaired ability to absorb the fat of the diet. The percentage of fat in the dry stool ranged between 22.5 and 49.0 per cent. As the number and character of the stools have been normal, it has been assumed that the dietary fat has been digested but absorption has been inadequate.

In addition to epigastric fullness, 4 patients complain of epigastric and substernal burning, usually experienced 15 to 30 minutes after meals. This symptom frequently follows the ingestion of fruit juices. It is temporarily relieved by taking alkalies.

All of the patients operated upon over a year ago have resumed a major portion of their normal occupations. Four of them, all men, have returned to their regular jobs. The 2 women do housework. One patient, 12 months after operation, is able to do only light work at irregular intervals. One patient, 4 months after operation, does a limited amount of light work. Two patients have been unable to return to work, one 8 months after operation and the other 4 months after operation.

Ferrous iron has been given at regular intervals to all of these patients; hemoglobin values and red cell counts of the blood of all of them have remained within normal limits. Normal blood prothrombin and bilirubin values have also been found consistently in all of these patients. These studies will be reported in greater detail.

SUMMARY

In the past, total gastrectomy has usually been reserved for the treatment of those malignant lesions of the stomach without distant metastases which could not be locally removed by subtotal resection. The high mortality rate of the procedure and the incidence of serious postoperative complications, together with the uncertainties of digestion and metabolism in the absence of the stomach, have restricted the use of total gastrectomy. If these objections can be obviated, undoubtedly block excision of the stomach and regional lymph nodes should be the most effective means of treating neoplasms of the pyloric and fundic regions of the stomach. The present series of 20 total gastrectomies with 2 operative deaths, together with the recent reports of other writers, indicates that the operative mortality of total gastrectomy is no longer prohibitive.

The available information concerning the digestion and metabolism of gastrectomized patients has been limited and uncertain. The postoperative study of these patients, 7 of whom have now survived for a year, furnishes additional evidence that such patients can maintain a fairly satisfactory nutritional state with special medical and dietary supervision. Six of these patients have returned to their former occupations. All of the patients now surviving have gained weight. The gains in weight have not been large, however, ranging from 2 to 12 pounds. The hemoglobin value in all cases is within the normal range. All of the patients are having from 1 to 3 normal bowel movements a day, although preliminary metabolic studies in 3 patients indicate an impairment of absorption of the dietary fat. They uniformly have a good appetite and are now taking a full diet divided into 4 to 6 meals a day. Recent roentgenograms, in all cases but 1, show a normal passage of barium through the anastomosis and remaining intestinal tract. One patient has a slight delay in the passage of barium through the anastomosis.

The lack of adequate gain in weight, the excretion of abnormal amounts of fat in the stools, the slow return of normal muscular strength, and the persistence of occasional attacks of abdominal fullness and epigastric burning, are still problems to be solved, possibly by new surgical procedures or by improved postoperative medical management.

CONCLUSIONS

Total gastrectomy offers the most effective means of eradicating gastric carcinoma of the pyloric antrum and fundus. Since it is possible to perform total gastrectomy with a mortality rate of less than 10 per cent, and since the evidence at present indicates that gastrectomized patients maintain a fairly satisfactory nutritional state, the more frequent use of the procedure is recommended. Certain lesions that would be considered inoperable if only subtotal gastric resection were employed, may be adequately treated by total gastrectomy. Malignant lesions of a less extensive nature should be removed by total gastrectomy if adequate excision of the involved stomach and regional lymph nodes by subtotal resection is considered a doubtful undertaking.

Gastrectomized patients present problems associated with adequate intake and absorption of food, sometimes persisting for months after operation, which at present prevent the recommendation of the procedure as the operation of choice for all malignant tumors of the stomach which are amenable to surgical treatment.

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COMPLICATIONS FOLLOWING THE USE OF COTTON AS SUTURE MATERIAL

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THE use of spool cotton as suture material in surgery is now well established and has been employed routinely in many outstanding surgical clinics in this country for several years. Ever since the appearance of the results of the experimental work of Meade and Ochsner (7), the reports in the literature have been uniformly enthusiastic in their support of cotton. Complications following its use have been so rare as to warrant their publication as individual case reports (1). Cotton as suture material was first used routinely in all my cases early in 1943 and it seemed entirely satisfactory, as I had anticipated. However, after a few months, complications which were considered directly attributable to the suture material began to be encountered with sufficient frequency to prompt me to investigate the cases with a view to determining the incidence and causes of these complications. In the cases in which the wounds healed without complications, I, as well as others, had noted that the healing and scars were so far superior to those in which catgut had been used, that it was considered undesirable to discontinue the employment of cotton without investigation.

After the study had been begun, more and more surgeons were found who objected to the use of cotton for various reasons. Most of them, however, had had little personal experience in its use and were not sufficiently familiar with specific cases in which it had proved unsatisfactory to warrant publication of their results. A notable exception to this group was Key, who stated that he had given cotton a trial only to abandon it and return to the use of catgut. He particularly objected to its use in orthopedic operations where it was buried over a gliding surface such as a joint. Although certain writers have mentioned instances in which it has been extruded from wounds, this complication is not considered serious because it has not been accompanied by the chronic draining sinuses so commonly encountered when other types of nonabsorbable sutures have been employed.

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The main advantages that have been claimed for cotton are its pliability, decreased tissue reaction, adequate tensile strength, high coefficient of friction and stability on exposure to heat and moisture (2, 3, 5, 6, 8, 9). Another distinct advantage is the fact that it encourages the surgeon to be gentle in the handling of tissues. All of these claims are perfectly logical and just. However, extravagant claims have been made and it is thought that one writer was slightly overenthusiastic when he attributed the lower postoperative febrile reaction in a group of patients who had undergone herniorrhaphies to the fact that they had been repaired with cotton (10).

It has been repeatedly pointed out by Ochsner and others that the successful use of cotton depends upon strict observance of the tenets of Halsted, which are as follows:

1. Use interrupted sutures only.
2. Never use coarse suture material.
3. Never bridge over a dead space as a cord subtends an arc.
4. Use transfixion sutures in ligation, as finer material can be used in this way.
5. Use a greater number of fine stitches rather than a few coarse ones.
6. Avoid the combined use of absorbable and nonabsorbable sutures.

METHODS AND MATERIAL

The present report is based upon 372 operations of various types performed in three different hospitals in which cotton was used as suture material either alone or in conjunction with catgut. The only cases in which the two materials were used together were in laparotomies in which the peritoneum was sutured

TABLE I.—IMMEDIATE POSTOPERATIVE COMPLICATIONS

Case No.	Operation	Type of complication
3	Thyroidectomy	Severe infection
7	Herniorrhaphy	Superficial infection
10	Appendectomy	Severe infection
29	Herniorrhaphy	Hematoma
41	Leg amputation	Superficial slough
53	Enterostomy	Deep abscess
79	Closure of colostomy	Deep abscess
87	Appendectomy	Slight infection
91	Herniorrhaphy	Maceration of skin
95	Appendectomy	Severe infection
110	Cholecystectomy	Superficial infection
124	Right colectomy	Wound disruption
125	Cholecystectomy	Wound disruption
133	Tenorrhaphy	Superficial infection
135	Leg amputation	Superficial infection
137	Open reduction of compound fracture	Superficial infection
150	Tenorrhaphy	Superficial infection
172	Ramstedt	Small stitch abscess
173	Thyroidectomy	Severe wound infection
193	Open reduction	Severe wound infection
219	Appendectomy	Deep wound infection with extensive slough
257	Herniorrhaphy	Small hematoma
260	Herniorrhaphy	Superficial infection
275	Herniorrhaphy	Superficial infection
306	Closure of perforated ulcer	Deep abscess
318	Gastrotomy	Deep abscess
327	Salpingo-oophorectomy	Intestinal obstruction, severe infection
343	Appendectomy	Deep abscess
370	Herniorrhaphy	Superficial infection

with continuous chromicized catgut, the remainder of the structures with interrupted cotton. Ordinary long fiber spool cotton, sterilized by autoclaving, was employed in every case. Only three sizes were used: No. 60 for ligature of small vessels, No. 30 for suture of the deep fascia and ligature of larger vessels, and occasionally heavy crochet cotton for ligature of still larger vessels. In the type of operations performed it was seldom necessary to use the heavy cotton. The tenets of Halsted were followed except for the combined use of absorbable and nonabsorbable sutures as mentioned.

The series included 34 different types of operations, of which 158 were laparotomies, 74 orthopedic procedures of various types, and the remainder herniorrhaphies, thyroidectomies, repair of deep traumatic wounds, kidney operations, mastectomies, and excision of subcutaneous tumors. Cotton was used indiscriminately whether or not the wounds were infected or contaminated.

The patients were carefully observed for from 4 to 18 months. The original wounds were classified as either clean or contaminated. A contaminated wound is defined as one in which there was previous soiling from outside sources or in which an obviously infected organ such as a perforated appendix was removed. Postoperative wound complications were carefully watched for and the most trivial ones reported (Table I). There were 311 (83.6 per cent) clean and 61 (16.4 per cent) contaminated wounds. The complications ranged in severity from complete disruption and deep abscesses to small hematomas and maceration of the skin edges.

There were 29 cases (7.7 per cent) with early postoperative complications, 15 of which were severe, 14 trivial. The most serious early complication, wound disruption, occurred in 2 cases. These are interesting in that this complication is seldom encountered when wounds have been sutured with cotton. Both of these instances occurred in gravely ill patients, one having undergone a one stage resection of the right colon for carcinoma, the other, a cholecystectomy for a ruptured gall bladder with generalized bile peritonitis. Secondary suture with through-and-through silk sutures was carried out in each case with uneventful healing. The appearance of the wounds at the time of secondary closure was interesting in that very little cotton could be seen and the small amount present was fragmented. It is thought that this complication cannot be solely attributed to the suture material as there were obviously several other factors responsible which are usually found in all cases of wound disruption regardless of the type of suture material employed. Further reference to Table I will reveal that the remainder of

the early postoperative complications were in no respect unusual and the same that might be seen in any similar series of operations.

Table II shows the late complications encountered. In this class were also included all of the complications no matter how trivial. It was considered of particular importance to note whether or not any cotton knots were extruded from the depths of the wounds. The occasional extrusion of a cotton knot, if it did not interfere with wound healing, was not considered serious. However, the patient frequently attaches undue significance to this and in 2 cases which were not considered serious or complicated from the standpoint of healing, there were threats of litigation. It may seem strange to some readers that there were such threats even though the eventual wound healing was retarded little if any. However, in this region for many years nonabsorbable sutures have never before been used on a large scale and the patients are educated to believe that all deep sutures should be absorbed.

The cases showing late complications naturally fall into two groups, the mild and the serious. The former has been explained. If a large number of knots are extruded or if the suture material was considered definitely to interfere with the healing of the wound, the complication must be regarded as serious. All of those cases in which it was thought that the suture material alone was not responsible for the difficulty were excluded from this group. According to this criterion, it is seen that of the 17 cases with late complications (4.5 per cent), 9 (2.4 per cent) were considered serious. Further reference to Table II reveals that the complications often did not appear until several weeks or months after the wound had healed. At the present time all of the wounds are healed, even though exploration was necessary in 3 cases which will be considered in some detail below.

An attempt was made to discover whether or not any common denominator could be applied to the cases with late complications. It was discovered early in the study that the cases did not follow any definite pattern in regard to infection. For example, there were several perfectly clean wounds from which

TABLE II.—LATE COMPLICATIONS

Case No.	Operation	Type of complication	Time of appearance
3	Thyroidectomy	Extrusion of 1 knot	14 months
4	Thyroidectomy	Extrusion of 2 knots	2 months
19	Mastectomy	Extrusion of 1 knot	6 weeks
74	Closure of colostomy	Extrusion of many knots, healed after 5 months	2 weeks
85	Appendectomy	Sinus for 4 months; exploration necessary	Immediately
86	Ureterolithotomy	Sinus for 3 months	Immediately
91	Herniorrhaphy	5 knots extruded	5 weeks
95	Appendectomy	Drained for 4 months, many knots extruded	Immediately
119	Appendectomy	5 knots extruded	4 weeks
132	Open reduction	Many knots extruded	6 weeks
133	Tenorrhaphy	2 knots extruded	3 weeks
137	Open reduction	Drained 4 months; many knots extruded	3 weeks
150	Tenorrhaphy	2 knots extruded	2 weeks
173	Thyroidectomy	Draining sinus 5 months, exploration necessary	1 week
183	Hysterectomy	Drainage for 9 months, exploration necessary	2 months
219	Appendectomy	2 knots extruded	1 month
280	Thyroidectomy	1 knot extruded	3 months

cotton was extruded or had to be removed at a later date after healing had progressed uneventfully. On the other hand, there were several patients with perforated appendices and considerable peritonitis which healed uneventfully. One of the most striking of these was in a patient with a perforated appendix with massive fecal leakage into the peritoneal cavity; his general condition was complicated by rather severe diabetes. Cotton has also been used to close colostomies without causing difficulty.

Of the 17 cases with late complications, 9 were originally classified as clean wounds. Of these, 2 developed severe infections postoperatively. If these are added to the cases which were originally contaminated or infected, it is seen that there is a total of 10 cases in which infection was a conspicuous feature.

The 9 cases with serious late complications are naturally of the greatest interest and will

be considered in some detail. In all of these draining sinuses appeared at various times following operation and they all had one factor in common; they did not heal until all of the cotton had been removed, either by being extruded spontaneously or by surgical intervention. In 3 cases it was necessary to explore the wounds, remove many cotton sutures from the deep fascia and resuture them with catgut. This was followed by prompt healing in each instance. Two of the wounds had been grossly infected, one operation having been performed for a perforated appendix with considerable peritonitis, the other a thyroidectomy which was followed by a deep abscess. The third case, a total hysterectomy, was perfectly clean, healed by first intention with a minimum of reaction, remaining healed for 2 months, at the end of which time two sinuses appeared. Many knots were extruded or were removed with forceps but drainage continued. Consequently, at the end of 5 months, it was necessary to explore the sinuses and remove the remaining sutures in the deep fascia. This was followed by prompt healing.

During the latter part of the period comprising the study, it was thought that infection was the commonest cause of difficulty and the use of cotton was discontinued in cases in which infection or contamination were present.

The patients were also examined with a view to discovering whether or not cotton was unsuitable for any particular type of wound. In the 4 most common types of operation—laparotomies of all types, orthopedic procedures, thyroidectomies, and herniorrhaphies the incidence of late complications was noted. Out of 158 laparotomies there were 6 complications (3.8 per cent). In 74 orthopedic procedures there were 2 complications (2.7 per cent). In 46 herniorrhaphies there was 1 (2.2 per cent). In 32 thyroidectomies there were 3 (9.3 per cent). When broken down in such a manner it is acknowledged that the series of operations is entirely too small from which to draw any definite conclusions. But here again, with the exception of the thyroidectomies, infection seems to be the only factor that appears with any degree of consistency whatever. The question as to whether or not the quantity of cotton buried in any one wound will have any effect upon the healing also arose. If this were true, one would expect to find more difficulty with the thyroidectomies than with any of the other types of operations, as much more cotton is used in them. This was not found to be the case.

The series was arbitrarily divided into three parts on a chronological basis. In the first one-third there were 9 complications; in the second, 7; while in the last one-third there was only 1. One possible explanation for this is that the writer became more and more adept in the use of cotton and more meticulous in his technique with the passage of time. Even though he had had previous experience in the use of nonabsorbable suture material in the form of silk, he had become thoroughly accustomed to the use of catgut, which had been employed for several years. Although every effort was made to carry out each procedure as meticulously as possible, early in the series it was found that there was a natural tendency to use cotton in a fashion similar to that in which silk had been used; it was frequently found that too much tissue had been included in a ligature, for example. However, the better results in the last group may be partly due to the fact that no contaminated cases were included. The decreasing incidence of complications might also be due to the fact that in the last group insufficient time had elapsed for all of them to appear. But in the vast majority of cases the complications occurred within the first 4 months and all of the cases were observed for at least that length of time.

DISCUSSION

While it is not considered that all of the causes of complications have been found, from the analysis presented, it seems that the most conspicuous single factor in the complicated wounds is infection. Although it was a factor in only a slight majority, it is regarded as sufficiently important to cause the writer to feel that cotton is not the suture material of choice in such cases, in spite of many opinions to the contrary. Emphasis must also be placed upon surgical technique in the use of this material and it is considered that the results, at least in the clean cases, should show further

improvement. It is thought that an incidence of serious postoperative complications due to suture material of 2.4 per cent is entirely too high, and the 3 cases in which the deep sutures had to be removed would be sufficient to cause many surgeons to abandon cotton entirely. A word of warning is believed in order to the surgeon who has been accustomed to the use of catgut and considers adopting cotton.

CONCLUSIONS

1. A series of 372 operations in which cotton suture material was employed is presented.

2. There were 17 cases (4.5 per cent) with late complications attributable to the suture material, which is considerably higher than the incidence encountered in the literature. Of these, 9 were considered serious and 8 mild.

3. Two early complications in the form of wound disruption were encountered, which is very rare according to the literature.

4. Infection did not seem to be present frequently enough to attribute all of the bad results to it.

5. Complications were present more frequently in the earlier than in the later cases in the series, and it is suggested that this may be due to improvement in technique in the later cases as well as to the fact that the use of cotton was finally given up in obviously infected or contaminated cases.

6. While cotton is still considered an excellent suture material, contrary to general opinion, it is not entirely without hazards and has definite limitations.

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THE EVOLUTION OF ADENOMAS OF THE LARGE INTESTINE AND THEIR RELATION TO CARCINOMA

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THE present day active search for the smallest tumors which may be recognized as malignant has added a new importance to many lesions previously considered insignificant. During the last few years there has been an increasing effort on the part of pathologists to recognize carcinoma in its preinvasive stage. By repeated biopsies Schiller was able to show that certain lesions of the cervix were followed eventually by an invasive carcinoma. Broders applied the phrase "carcinoma *in situ*" to describe this noninvasive stage of carcinomas of glandular and of squamous cell origin. Both Verse and Dukes observed the presence of carcinoma in polypoid adenomas of the large intestine, a picture which would appear to correspond to the "carcinoma *in situ*" of Broders. Moreover, the literature attests that this picture has been noted by many workers. Nevertheless, the exact relation of adenomas to carcinomas of the large intestine has remained controversial.

Adenomas constitute the great majority of polyps occurring in the large intestine (10). Confusion in the literature has resulted from the different interpretation of the term polyp. By some authors, the term polyp is used to designate any sessile or pedunculated benign tumor arising in the mucosa or wall and projecting into the lumen of the intestine. While this interpretation indicates the gross appearance of the tumor, it does not signify the exact pathologic type. On the basis of histologic examination the generic classification of polyps may be divided into several different specific types of tumors such as adenomas, lipomas, leiomyomas, and carcinoids. By other authors the term polyp has been considered synonymous with adenoma. In order to avoid this confusion of terminology it would seem best to designate these tumors according to their specific structure. In this paper the term adenoma is used to designate either a sessile or pedunculated benign tumor of glandular origin. In accord with this restricted interpretation of the term adenoma, I have excluded from this study all other types of tumors, hemorrhoids, fibrous tags, and lesions obviously the result of infection.

The problem of the relation of adenomas to carcinomas of the large intestine has usually been investigated by one of two different methods. First, information about adenomas has come from observations made on patients at frequent intervals. While this method of study is advantageous, it is also incommodious. Furthermore, it is not an ideal therapeutic procedure to follow the course of an adenoma over a period of time and determine whether a transition from benignancy to malignancy occurs. The second method by which information has been gained has come from the observation in adenomas of histologic changes commonly recognized as diagnostic of carcinoma. Many of the investigations in which adenomas have been examined for histologic foci of carcinoma have been undertaken on small segments of the colon removed at surgical operation. Other investigations, in which there has been no concerted effort to determine the exact occurrence of adenomas or to examine all of them carefully, have been carried out on colons removed at autopsy. It seemed that a more definite understanding of the relation of adenomas to carcinomas of the large intestine could be gained by a careful determination of the incidence of adenomas at autopsy and the analysis of each adenoma for the presence or absence of histologic changes commonly recognized as diagnostic of carcinoma.

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MATERIALS AND METHODS

The present report is based upon a study of 1460 consecutive autopsies in which the entire large intestine was available for examination. Each large intestine was carefully examined in the fresh state. All sessile and pedunculated mucosal elevations together with the contiguous wall of the colon were removed and fixed in 4 per cent formaldehyde. The site of each lesion was noted and its distance from a specific landmark was recorded. After fixation, notes and drawings were made of each lesion. If a lesion was large it was divided one or more times along a plane perpendicular to the mucosa. Specimens were then embedded in paraffin in such a manner that the plane of the section was at a right angle to the plane of the mucosa. At intervals throughout each block, step and serial paraffin sections stained with hematoxylin and eosin were prepared. Unstained sections contiguous with the stained sections were saved until after the stained sections were observed. Additional sections were prepared when deemed necessary. The microscopic findings were then noted and compared with the gross appearance.

CLASSIFICATION OF ADENOMAS

A great deal has been written about the classification of adenomas of the large intestine (2, 5, 7, 8, 13, 16, 17, 21). Most of the proposed classifications have been based upon (1) apparent etiologic factors such as ulcerative colitis; (2) clinical features such as the singularity or multiplicity of the tumors and the age of the patient, and (3) the character of the morphologic and histologic structure of the tumor.

The adenomas studied in the present series of cases have not yielded evidence to support the concept of an associated inflammation as the inciting agent of the adenomas. Although most of the more common types of colitis were encountered in the present series of autopsies, only one example of the association of colitis and adenomas was observed. In the colon of a 67 year old man, a single adenoma and amebic ulcers were present. It would appear from this series that any relation between the presence of some form of colitis and adenomas is purely coincidental.

The clinical picture of familial adenomatosis or multiple polyposis of the large intestine is well established. However, it is impossible to determine any fundamental differences in the adenomas occurring in familial adenomatosis and those occurring singly. The gross and microscopic features of adenomas noted in the one example of familial adenomatosis in this series could be duplicated in any number of colons containing one or only a few adenomas.

The literature contains many references to classifications based upon either or both the macroscopic and microscopic appearance of adenomas. It is claimed that the contour of the tumor and the regularity or irregularity of the surface are useful criteria regarding classification. Much importance has been attached to the microscopic appearance of the epithelium and to the connective tissue framework. It seems doubtful that any significance, such as was suggested by Hauser, can be attributed to the amount of degenerated epithelium. In the present series degenerated epithelium occurred in adenomas in an indiscriminate manner. Likewise, the separation of adenomas into three groups as proposed by Fitzgibbon and Rankin (8) and others (9) seems to be of questionable usefulness. These authors, on the basis of the histologic picture, felt able to determine that certain adenomas were destined for a long and benign course. Such a degree of faith in the interpretation of a histologic section does not seem warranted. In the present series many of the adenomas when studied by step and serial sections did not show a uniform cytologic and histologic picture. No evidence could be adduced that any particular group of adenomas would maintain a constant benign course. It does not seem justifiable to predict that a selected group of adenomas will not contain a focus of carcinoma at some future date. These same authors also were presumably able to determine the age of an adenoma by the microscopic appearance. The observations in the present study did not give any clue as to the age of an adenoma. It seems doubtful that the age of an adenoma can be determined except by observation of the tumor in a patient over a period of time.

On the basis of the present study no distinguishing morphologic and histologic characteristics which would seem to warrant a complex classification of adenomas were noted. In all instances the adenomas appeared basically similar, and no practicable significance could be attached to minor variations of structure and cells.

MORPHOLOGY AND EVOLUTION OF ADENOMAS

The gross appearance of adenomas has been described many times. In the present series the tumors varied in size from 1 millimeter to 9 centimeters in diameter. The smaller tumors in some instances occurred on the summits of mucosal folds and at other times arose from the flat mucosa. There did not appear to be any definite pattern for this phenomenon since intestines with multiple adenomas were likely to show involvement of both sites. Moreover, a comparison of those adenomas of similar size which were situated on the summits of folds with those arising from the flat surface frequently showed a longer pedicle on the former. This picture suggests that the site of the adenoma may influence the development of the pedicle. Those adenomas situated on a mucosal fold would be more exposed to peristaltic action of the intestine.

It is common practice to describe adenomas as pedunculated or sessile. Many of the tumors present an obvious pedicle and may be correctly termed pedunculated. The group of tumors referred to as sessile do not present such an obvious picture. These tumors are commonly hemispherical in shape and on the basis of the external configuration appear sessile. However, in most instances, a midsagittal section through the tumor reveals a short central stalk with tumor overhanging the margins like an umbrella. In reality many adenomas with the appearance of sessile tumors are actually pedunculated, and only a few tumors are truly sessile. Even when an adenoma covers a large surface and appears sessile there may be numerous individual stalks supporting closely approximated polypoid projections.

The contour of the adenomas may be regular, lobulated, or villous. Both the pedicle and the tumor frequently are flattened in one dimension. Not only may different adenomas in one colon exhibit various configurations, but occasionally a single adenoma may show diverse forms of contour. In general the smaller tumors are more likely to show a regular outline and the larger adenomas a definitely lobulated or villous form. Likewise the smaller tumors tend to be gray in color and the larger tumors grayish red or red. However, these tinctorial qualities are not constant, and a fair proportion of the tumors will exhibit both red and gray foci. The color is determined by the richness of the vascular supply, by the degree of congestion, and by foci of hemorrhage, inflammation, and ulceration.

Because of the protean histologic structure of adenomas, it is difficult to describe any particular picture as typical. The small tumors are disposed to have a more simple framework than are the larger ones. Usually this consists of a single connective tissue core with or without an extension of the muscularis mucosae into the stalk. When the adenomas are minute, a definite connective tissue stalk may be absent. In such instances the histologic picture is primarily one of epithelial hyperplasia. The epithelial hyperplasia brings about either an increase in the size of the glands or in the number of glands or both. Usually there is no appreciable disposition to stratification of the cells or to papillary infolding. The epithelial cells may or may not be distended with mucus but otherwise are not particularly abnormal. An essentially similar picture has been described by Dukes, who observed patches of epithelial hyperplasia in the vicinity of carcinomas of the colon. Dukes considered these patches of epithelial hyperplasia to be the first step in the formation of adenomas. The location of the epithelial hyperplasia has been thought by Bargen, Cromar and Dixon (1) to be determined by the site of the lymphoid follicles in the intestine. According to these authors a subclinical inflammatory process produces a rupture of the lymphoid follicles, and the subsequent repair results in an isolation of a portion of epithelium by a ring of lymphoid tissue. This process may result in the formation of an adenoma or because of a change in the envi-

ronment of the cells give way to malignant neoplasia. This theory is hardly tenable in the light of the observations in the present study. Microscopic examination of the smallest adenomas disclosed some with lymphoid follicles situated in the stroma beneath the epithelial hyperplasia and others without lymphoid nodules. If the lymphoid nodules are an essential factor in the evolution of the adenoma then they should be found in all examples. Moreover, lymphoid nodules undergo hyperplasia in other organs such as the appendix, small intestine, and thyroid and are not associated with the development of adenomas. As will be brought out subsequently, adenomas of the large intestine are less common in the negro than in the white race although there is no evidence that negroes have fewer lymphoid nodules or less clinical or subclinical inflammation of the large intestine. The lymphoid nodules normally are located internal or external to the muscularis mucosae and in some instances partially obscure it. There is no constant location of the nodules, when present, relative to the epithelial hyperplasia. They may appear either directly beneath the epithelial hyperplasia or at the margin. This suggests that there is no direct relation between the site of the lymphoid nodule and the development of the adenoma. It is not surprising that some adenomas show one or more lymphoid nodules in the immediate vicinity. The adenomas are subjected to peristaltic action and frequently show infiltration of inflammatory cells, hemorrhage, and deposits of hemosiderin. Lymphoid nodules are normally present in the large intestine and large lymphoid follicles with secondary nodules commonly occur in inflammation. Thus a subjacent prominent lymphoid nodule might be expected to occur as a result of inflammation within the tumor. The lymphoid nodules occasionally observed at the margin of lipomas and carcinoids of the colon probably occur for the same reason. On the basis of this evidence it seems more logical to conclude that the lymphoid nodules are not an important factor in the mechanism of development of adenomas but are coincidental and undergo hyperplasia as the result of the presence of the tumor.

As the adenomas increase in size the supporting connective tissue structure tends to become more complex. In the largest tumors it is common to observe not only a central stalk but also a number of branches which support the polypoid or villous processes. The central stalk and branches are comprised of connective tissue and in some tumors contain strands of smooth muscle. The smooth muscle may or may not be continuous with the muscularis mucosae. The connective tissue frequently shows a variation in the degree of cellularity, not only among all adenomas but in different fields of a single tumor. The stroma is sometimes dense and hyalinized and at other times tenuous and cellular. The extent of the vascularity of the stalk is also variable. In most adenomas, the larger tumors, in particular, one or more large blood vessels is present. Occasionally the walls of the arteries are thickened and are the seat of hyalinization. Some adenomas contain arteries and veins occluded by thrombi. All stages of organization are represented among the thrombi. In some instances the thrombi appear to be secondary to the inflammatory process. This is especially evident when the involved area is limited to the superficial or exposed segment of the tumor. In other examples the thrombi are not accompanied by an appreciable inflammatory reaction. It is conceivable that the thrombi in these adenomas are the result of trauma or twisting of the pedicle of the tumor.

The architectural pattern of the glands forming the larger adenomas may appear essentially similar to that of the small tumors previously described. More frequently, the glands in the larger tumors exhibit abnormalities such as elongation, dilatation, branching, and papillary infolding. The character of the epithelial cells lining the glands shows little change from normal. The cells are usually tall and columnar, sometimes have an elongated and compressed appearance, and may or may not be predominately of the mucous type. The nuclei are moderately chromatic and usually do not show large nucleoli. There is a distinct tendency for the nuclei, which are sometimes elongated, to occupy the basal portion of the cells. Mitotic figures may be

TABLE I.—INCIDENCE OF ADENOMAS IN WHITE PATIENTS

Age groups years	Males	With adenomas	Per cent	Females	With adenomas	Per cent	Totals Patients	With adenomas	Total per cent
0–1	128	0	0.	100	0	0.	228	0	0.
1–10	51	2	3.9	28	0	0.	79	2	2.5
11–20	43	0	0.	30	1	3.3	73	1	1.3
21–30	53	0	0.	29	0	0.	82	0	0.
31–40	64	7	10.9	46	2	4.3	110	9	8.2
41–50	85	8	9.4	53	3	5.6	138	11	7.9
51–60	158	26	16.4	74	11	14.8	232	37	16.
61–70	130	30	23.	58	10	17.2	188	40	21.2
71–80	85	22	25.8	39	8	20.5	124	30	24.2
81–90	16	3	18.7	8	1	12.5	24	4	16.6
91–100	1	0	0.	0	0	0.	1	0	0.

TABLE II.—INCIDENCE OF ADENOMAS IN NEGRO PATIENTS

Age groups years	Males	With adenomas	Per cent	Females	With adenomas	Per cent	Totals	With adenomas	Total per cent
0–1	33	0	0	23	0	0	56	0	0
1–10	5	1	20	1	0	0	6	1	16
11–20	6	0	0	1	1	100	7	1	13
21–30	14	0	0	0	0	0	14	0	0
31–40	11	0	0	11	0	0	22	0	0
41–50	14	0	0	9	0	0	23	0	0
51–60	11	0	0	12	0	0	23	0	0
61–70	11	1	9	7	1	13	18	2	11
71–80	8	1	12	2	0	0	10	1	10
81–90	0	0	0	1	0	0	1	0	0
91–100	0	0	0	1	0	0	1	0	0

frequently encountered. Stratification of the epithelial cells is uncommon, and there is a definite line of demarcation of the epithelial cells from the contiguous stroma. If the tumor is pedunculated, normal-appearing mucosa commonly covers the pedicle or base of the stalk.

Swinton and Warren have stated that adenomas usually show no evidence of inflammatory reaction other than slight lymphocytic infiltration at the base. This observation is contrary to the observations made in the present study. I have found that adenomas, the larger ones in particular, contain inflammatory cells, including lymphocytes, plasma cells, monocytes, and neutrophilic and eosinophilic polymorphonuclear leucocytes. Several tumors contained foci of acute inflammation, small abscesses, and ulceration. Serial and step sections of a single adenoma may disclose acute inflammation in some sections and not in others. It is possible that some of the dense connective tissue within adenomas represents the former sites of inflammation. That the adenomas are subjected to severe trauma is verified by the frequent observation of hemorrhage and intracellular and extracellular deposits of hemosiderin within the stroma of the tumors.

Many authors have attributed the development of adenomas in the large intestine to some form of antecedent inflammation. In the present study it was rarely possible to demonstrate gross or histologic changes of a previous inflammation in the mucosa or wall of the intestine. This observation does not deny that small or minor foci of inflammation had not previously occurred followed by complete repair or the evolution of an adenoma—neither does it support such a concept. However, it does seem unlikely that an inflammatory process such as ulcerative colitis could regress without leaving evidence of chronic inflammation, atrophy, or fibrosis. Since one person in five who reaches the age of 60 has an adenoma of the large intestine, it is reasonable to expect some people with adenomas to reveal a past history of colitis. A previous history of colitis should not then necessarily implicate the colitis as the etiologic agent of adenomas. The observations in the present study coincide with the opinion of Swinton and Warren that adenomas of the large intestine are true tumors and are not the result of diffuse inflammatory processes.

THE INCIDENCE OF ADENOMAS

The large intestine in each of 1,460 consecutive autopsies was examined. Of this number, 139 or 9.5 per cent contained adenomas. After 1 case of familial adenomas was excluded, the remaining 138 specimens contained 272 tumors. Four of the tumors were unsatisfactory or unavailable for detailed mi-

Fig. 1.

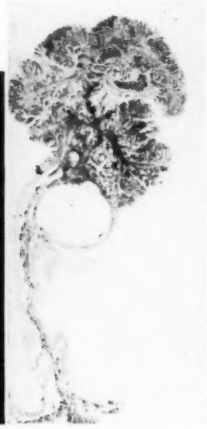

Fig. 2.

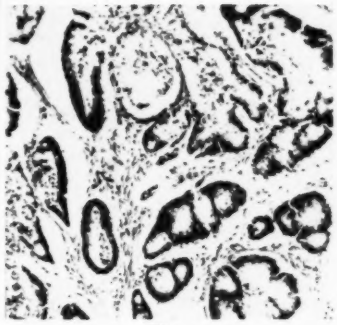

Fig. 3.

Fig. 1. Gross specimen of an adenoma of the pedunculated type. ×1.7.
Fig. 2. Photomicrograph of the adenoma shown in Figure 1. The stalk is covered with normal mucosa. There is a large cystic space partially lined by epithelium at the base of the adenoma. ×1.9.
Fig. 3. High power photomicrograph showing histologic carcinoma in the base of the adenoma pictured in Figure 2. The irregular glands show intraglandular budding and invasion of the stalk. The nuclei are hyperchromatic and there is a variation of the nuclear polarity. ×70.

croscopic study and were considered as benign adenomas.

In Table I the incidence of adenomas of the large intestine of 1,279 white patients is given, and in Table II similar figures are presented for 181 negro patients.

The incidence of adenomas in the 1,279 white patients was 10.4 per cent. When the incidence is studied by age groups, a fairly constant progressive increase is noted above the age of 30 in both sexes. The peak incidence was reached in the eighth decade when 25.8 per cent of the men and 20.5 per cent of the women showed adenomas. In all decades above the third slightly more men than women had adenomas. This observation, although not so pronounced, is in agreement with the results of Lawrence who noted that more white males over 40 years of age had adenomas of the colon than did white females, by the proportion of 1.6:1.

The number of negro patients examined, 181, is admittedly small. The overall incidence of adenomas in this groups was 2.7 per cent compared with 10.5 per cent in the white patients. If only those patients over 30 years of age are included, the incidence in the negro race was 3 per cent compared with 16 per cent in the white race. From these figures it is evident that at least in the older age groups there is a greater disposition to the development of adenomas among the white race than among the negro race. Lawrence also noted a higher incidence in the white race but not such an appreciable difference.

In 80 of the 139 cases there were single adenomas, and in the remaining cases two or more tumors were noted. Saint noted that multiple tumors were slightly more common than were single tumors, but Lawrence observed a predominance of single tumors.

From Table III it is apparent that an individual 35 years of age with adenomas has about the same chance of having multiple tumors as does the person 75 years old. However, multiple adenomas are more common in older people because the incidence of adenomas is greater in older people. This observation would indicate that in many instances the factors initiating the development of adenomas act on multiple sites at about the same time.

The number of female patients—24—with single adenomas (63 per cent) is slightly greater than the number of male patients—

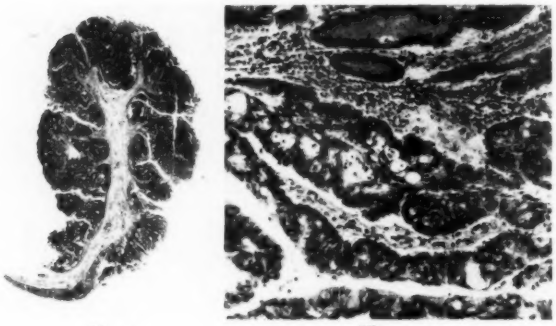

Fig. 4. Fig. 5.

Fig. 4. Photomicrograph of an adenoma of the pedunculated type. ×3.

Fig. 5. High power photomicrograph showing histologic carcinoma near the tip of the adenoma pictured in Figure 4. An abrupt transition in the character of the glands is apparent. There is marked stratification of cells and intraglandular budding. The cells vary in size and shape. The nuclei show a variable polarity and have prominent nucleoli. ×100.

56—with single tumors (55 per cent). Conversely more men—45 (45 per cent)—than women—14 (37 per cent)—have multiple tumors.

The sites of adenomas are shown in Table IV. In 80 of the 139 large intestines the adenomas occurred singly. However, 20 of the 59 intestines with multiple tumors showed localization of the tumors to one segment, and in 10 more instances the distribution of the tumors was confined to two contiguous segments such as the sigmoid colon and rectum or cecum and ascending colon. Thus in 100 of the 139 intestines the tumors were localized to one segment and in an additional 10 examples the tumors were localized to two contiguous segments. In the other 29 intestines the adenomas were scattered indiscriminately throughout, though at times more tumors were concentrated in one segment than in another. Thus in the group of tumors without localization, 9 of 12 tumors in the transverse colon came from only two intestines.

Fig. 6. Gross specimens of eight adenomas from a single large intestine showing the diverse sizes and shapes. Some of the adenomas have long pedicles whereas others have short stalks. The smallest adenoma measures 1.5 millimeters and the largest 20 millimeters in the greatest diameter.

In a previous paper (10) I have shown that adenomas of the colon are more frequent than adenomas of the rectum and that the sigmoid colon is the most common site of adenomas in the large intestine. As noted in Table IV, this latter observation holds true whether there are single tumors, multiple tumors localized to one site, or multiple tumors with a widespread distribution. After taking into consideration that many of the groups in Table IV are small and that the ratio of men to women examined in this series is 1.7:1, there is a general indication that the incidence of adenomas in men is greater than that in women in all sites of the large intestine regardless of singularity or multiplicity of tumors.

RELATION OF ADENOMAS TO CARCINOMA

In order to acquire further knowledge on the relation of adenomas to carcinoma of the

Fig. 7.

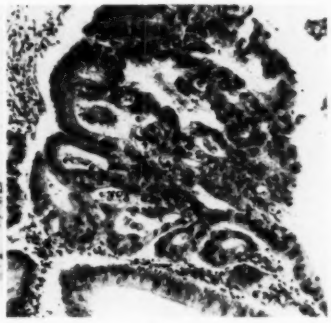

Fig. 8.

Fig. 7. Photomicrograph of the third adenoma from the left in the bottom row shown in Figure 6. There is a short stalk over which the normal mucosa extends for a short distance. ×2.7.

Fig. 8. High power photomicrograph showing histologic carcinoma at the margin of the shallow cleft in the superior surface of the adenoma pictured in Figure 7. The irregular atypical glands are not separated by a limiting membrane. The cells are pleomorphic. The nuclei are hyperchromatic and have large nucleoli. ×100.

Fig. 9.

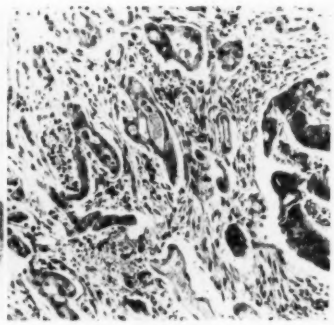

Fig. 10.

Fig. 9. Photomicrograph of an adenoma. There is a broad short stalk covered with normal mucosa. ×3.

Fig. 10. High power photomicrograph showing histologic carcinoma in the base of the adenoma pictured in Figure 9. There is little tendency to gland formation and the cells are pleomorphic. The nuclei vary in size and shape and have prominent nucleoli. The cell masses extensively invade the base of the adenoma. ×100.

large intestine, step and serial histologic sections of each tumor and the contiguous wall were analyzed. From these histologic observations it was clear that many adenomas exhibited minor variations in structure in different parts rather than a homogeneous picture. Furthermore, a few adenomas contained a focus or foci which resembled the structure of a carcinoma. These adenomas with foci of carcinoma were considered to represent the transition stage from benignancy to malignancy.

The establishment of the transition from simple adenoma to carcinoma is relatively difficult. In the manifest or unquestioned carcinoma the diagnosis is readily established by the invasion of the wall of the intestine. In addition to the invasion of the wall, the carcinoma is usually characterized by the formation of irregular glands, a certain de-

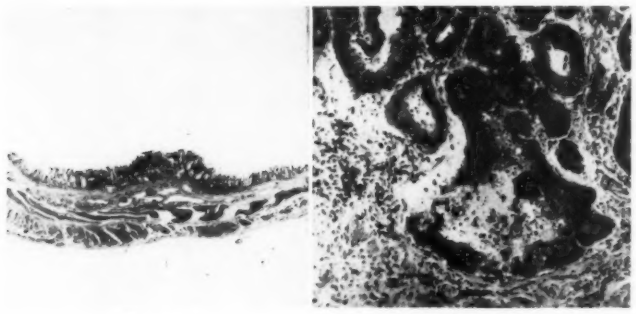

Fig. 11. Fig. 12.

Fig. 11. Photomicrograph of a small carcinoma not arising in an adenoma. ×3.4.

Fig. 12. High power photomicrograph of the base of the small carcinoma pictured in Figure 11. The glandlike structures have invaded the muscularis mucosa. The lining cells show stratification and a variable nuclear polarity. The cells are hyperchromatic and the nucleoli are large. ×100.

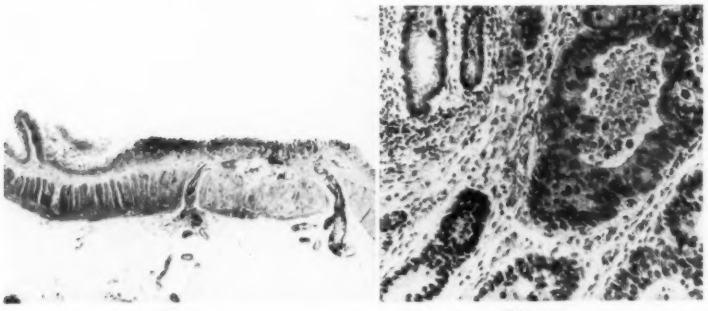

Fig. 13. Fig. 14.

Fig. 13. Photomicrograph of a small carcinoma not arising in an adenoma. Note the tumor within veins extending through the muscularis into the adjacent fat. ×3.

Fig. 14. High power photomicrograph of small carcinoma shown in Figure 13. The atypical glands show stratification and pleomorphism of the lining cells. The nuclei show variation of polarity, are hyperchromatic and have prominent nucleoli. ×100.

gree of anaplasia of the cells, and in some instances invasion of lymphatic and blood vessels. In the diagnosis of carcinoma arising in an adenoma the irregularity of the glands and the anaplasia are of paramount importance, since whatever invasion is present is likely to be limited to the stalk. It is well known that some carcinomas of the large intestine simulate the cell arrangement of an adenoma so closely that the diagnosis of a malignant tumor depends entirely on the invasion of the wall of the intestine. Obviously, a carcinoma of this type cannot be identified in an adenoma unless there is evident invasion.

In determining the presence of a carcinoma arising in an adenoma in this series, the general criteria suggested by Swinton and Warren have been used. These criteria are the presence of at least two of the following three conditions: (1) anaplasia, (2) irregularity of architecture and (3) invasion. The anaplasia is characterized by a variation in the size of the cells and nuclei, deep-staining nuclei with prominent nucleoli, and the presence of mitotic figures. The irregularity of architecture is characterized by either extensive stratification of cells or by intraglandular budding or by both. In all instances there is marked

TABLE III.—AGE AND NUMBER OF ADENOMAS

Age group-years	Sex	One	Two	Three	Four	More than four
1–10	M	2	1			
	F					
11–20	M					
	F	2				
21–30	M					
	F					
31–40	M	4	1	1		1
	F	1	1			
41–50	M	6				2
	F	3				
51–60	M	14	4	6	1	1
	F	7	2		1	1
61–70	M	16	7	4	2	1
	F	6	4			1
71–80	M	13	4	3	2	1
	F	5	1	2		
81–90	M	1	1			1
	F		1			

TABLE IV.—SITE AND NUMBER OF ADENOMAS

Site	Sex	Intestines with single adenomas	Intestines with multiple adenomas confined to one site	Intestines with multiple adenomas confined to two contiguous sites	Intestines with multiple adenomas without localization
Cecum	M	7	1	1	7
	F	3	2	1	2
Ascending colon	M	3	2	1	8
	F	4	2	2	3
Hepatic flexure	M	1	0	0	7
	F	0	0	1	0
Transverse colon	M	7	0	0	12
	F	1	1	0	1
Splenic flexure	M	1	0	0	8
	F	1	1	0	0
Descending colon	M	3	2	1	7
	F	2	0	0	1
Sigmoid colon	M	24	5	6	13
	F	9	0	1	3
Rectum	M	10	4	5	10
	F	4	0	1	2
Throughout	M				
	F				1

variation in the polarity of the nuclei. The intraglandular proliferation of cells produces glandlike structures and cell masses which are not separated by a limiting membrane. Invasion is recognized when no definite border is apparent between the epithelial cells and the surrounding stroma. Using these criteria as the basis for the determination of the presence of malignancy, all gradations from adenoma with foci of carcinoma to unquestionable carcinoma could be demonstrated (Figs. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10).

A factor of primary importance in the histologic diagnosis is the site involved in the transition from adenoma to carcinoma. Some authors believe that the site of transition from adenoma to carcinoma appears first at the tip of the adenoma, and others believe it occurs first at the base. In the present study no definite pattern could be established for the occurrence of the foci of carcinoma. In several instances the malignant change occurred at the periphery of the adenoma, either at the tip or at the margins. In other specimens the transition occurred deep within the tumor near the stalk and at the base. With this fact established, it is obvious that an accurate histologic diagnosis demands that an adequate number of sections be observed. The precision of the diagnosis will be proportionate to the care taken in the selection of representative sections. In a few adenomas the gross appearance of a firm solid gray focus was later confirmed histologically as a focus of carcinoma. Otherwise, there were no macroscopic identifying features of the malignant foci.

The smallest adenoma showing malignant change in this series measured 7 by 6 by 3 millimeters, and the largest, 9 centimeters in the greatest diameter. The median of the largest diameter of the tumors was 1.8 centimeters. Saint did not observe malignant change in any adenoma which was smaller than a walnut. In the present series several of the benign adenomas were larger than some of the adenomas with malignant foci. However, the adenomas with malignant foci as a group were larger than the class of benign adenomas.

When the incidence of adenomas and carcinomas in the negro race is contrasted with

the incidence in the white race a distinct difference is noted. As previously mentioned, only 2.7 per cent of 181 negro patients showed adenomas of the large intestine in contrast with an incidence of 10.5 per cent in the white race. If only those patients over 30 years of age are considered, then the contrast of the 3 per cent incidence in the negro race with the 16 per cent incidence in the white race is even greater. Furthermore, in this series of 181 negroes there was not a single instance of carcinoma of the large intestine. Karsner and Clark have analyzed the racial incidence in Cleveland of carcinoma of the large intestine. These authors state that Cleveland is a city with a large negro population, but in only 2 of 100 of their cases in which a note as to color was made was the patient a negro. Thus the data on racial incidence would indicate that both adenomas and carcinomas of the large intestine are uncommon in negroes.

Table V gives by age the incidence of (1) adenomas, (2) adenomas with foci of carcinoma, and (3) manifest carcinomas in the 1,279 white patients in the series covered by the present report. There were 134 patients with adenoma, 10 with adenoma with foci of carcinoma, and 25 with manifest or obvious carcinoma. From the figures in the table it is evident that in each of the three groups there is a greater incidence in the latter decades of the life span.

Among the entire group of 1,460 patients, both white and negro, there were 139 large intestines containing adenomas. Of these 139 intestines having adenomas, 10 or 7.2 per cent contained one or more adenomas with malignant transition. In 8 of the 10 intestines the transition to carcinoma occurred in only a single adenoma. In the other 2 intestines, carcinomatous change was present in 2 and 3 adenomas, respectively. Furthermore, 2 of the 10 intestines containing a single adenoma with carcinomatous transition and the one intestine with triple tumors of this type also contained an obvious or manifest carcinoma. When the adenomas with malignant transition and the obvious carcinomas are classed together, 4 of the 10 intestines each contained 2 or more malignant tumors. The occurrence of multiple primary malignant tumors has been reported by Warren and Gates and by Brindley. The findings in the present study agree with the concept that the presence of one malignant tumor does not protect against the occurrence of a second malignant tumor and that a patient with a carcinoma is more likely to have a second carcinoma develop than the patient who is free from malignancy.

TABLE V.—AGE AND INCIDENCE OF CARCINOMA

Age group	White patients examined	With adenomas		With manifest carcinoma		With carcinoma arising in adenomas		With carcinoma arising direct from mucosa	
		Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent
0–1	228								
1–10	79	2	2.5						
11–20	73	1	1.3						
21–30	82			1	1.5				
31–40	110	9	8.2	2	1.8	1	.9		
41–50	138	11	7.9	3	2.2	2	1.4		
51–60	232	37	16.	5	2.1				
61–70	188	40	21.2	11	5.8	6	3.2	1	0.5
71–80	124	30	24.2	3	2.4	1	.8	1	0.8
81–90	24	4	16.6						
91–100	1								

No informative data are gained from a morphologic study of the 25 examples of manifest carcinoma. In most instances the widespread growth of the tumor had destroyed the initial architecture making it impossible to identify pre-existing adenomas. Swinton and Warren were able to demonstrate that 14 per cent of the carcinomas of the colon arose in benign mucosal polyps and believed the percentage to be much higher.

In the 25 large intestines containing a manifest carcinoma, observed in the present series, there were associated adenomas in 13 instances. In the 10 large intestines containing an adenoma with carcinomatous transition there were associated adenomas in 8 instances. A comparison of the 25 cases of manifest carcinoma with the 10 cases of adenoma with carcinomatous transition shows that both groups were associated with additional adenomas in over 50 per cent of the cases. This common association is denied by Saint, who

stated that the two conditions are not frequently found in the same intestine. However, the figures in the present study lend support to the concept of an intimate association between adenomas and carcinomas.

Another important factor is the correlation between the distribution of the manifest or unquestioned carcinomas and the adenomas with carcinomatous transition. In this paper tumors which occurred within 15 centimeters of the mucocutaneous junction of the anus are designated as rectal. As would be expected, difficulty was encountered in determining exactly the site of carcinomas situated at the junction of two segments. If over 50 per cent of a tumor was located in a given segment, it was then assigned to that segment. The inability to identify correctly the segment in which the tumor is located probably explains the variation in the distribution of carcinomas of the large intestine as recorded in the literature. It was previously shown that the sigmoid colon is the most common site of benign adenomas. From Table VI it is evident that the sigmoid colon is also the most common site of adenomas with carcinomatous transition and of the manifest carcinomas. Likewise, benign adenomas, adenomas with malignant transition and manifest carcinomas frequently involve the rectum, cecum, and ascending colon and less frequently the flexures, transverse colon, and descending colon. Thus the distribution of the tumors is another line of evidence of the intimate relationship between adenomas and carcinomas.

The incidence of adenomas is slightly more common in men than in women. In the group of 25 patients with manifest carcinoma 15 were men and 10 were women. Of the 10 patients with adenomas showing foci of carcinoma 7 were men and 3, women. Since the ratio of men to women in the entire series of patients was 1.7:1 there were no significant sex differences in the three groups.

CARCINOMA ARISING DIRECTLY FROM THE MUCOUS MEMBRANES

Although there is much evidence that many carcinomas of the large intestine develop in previously existing adenomas, some carcinomas undoubtedly arise directly from the mucosa. In the present study two small or histologic carcinomas without morphologic evidence of a pre-existing adenoma were encountered. These small carcinomas contribute informative material for study which cannot be gained from carcinomas in the advanced state. Both of the tumors occurred in men. One of the carcinomas was located in the distal part of the descending colon and the other occurred in the distal part of the sigmoid colon. In neither instance were adenomas present anywhere in the large intestine. The smaller of the two tumors, located in the sigmoid colon, appeared as a moderately firm, gray, sessile elevation with a slightly depressed center. The diameters of the tumor were 6 by 5 millimeters and the height, 2 millimeters. The larger tumor was situated in the descending colon. It appeared as a firm gray sessile elevation with a slightly irregular surface. The diameters of the tumor were 11 by 13 millimeters. The periphery of the tumor was elevated up to 2 millimeters in height and the central area was slightly depressed. A transection of this tumor revealed gray streaks extending into the underlying submucosa and muscularis.

TABLE VI.—SITE AND INCIDENCE OF CARCINOMA

Site	Manifest Carcinoma	Carcinoma arising in adenoma	Carcinoma arising direct from mucosa
Cecum	3		
Ascending colon	4	3	
Hepatic flexure	1		
Transverse colon	1		
Splenic flexure			
Descending colon			1
Sigmoid colon	10	7	1
Rectum	6	3	

The microscopic characteristics of these tumors are illustrated in Figures 11, 12, 13, 14. A small segment of the mucous membrane contains a number of abnormal glands. However, not all of the glands within the given segment are altered. Thus, one or several abnormal glands are interspersed among essentially normal ones. The outstanding feature of the abnormal glands is the change in the character of the lining cells. This change may involve all of the cells lining a gland or only a few of them. The definition between the normal cells and the abnormal is occasionally abrupt. The altered cells are enlarged

but not uniformly so, and the cytoplasm stains intensely. The nuclei generally exhibit an appreciably greater enlargement than do the cells and are distinctly hyperchromatic. The nucleoli are likely to be enlarged and prominent. A survey of several cells shows a conspicuous variation of the nuclear polarity which contrasts sharply with the basal arrangement of the nuclei of the normal cells. A number of mitotic figures are noted. However, the presence of mitotic figures is of questionable significance because mitosis is a common occurrence in normal mucosa. Not uncommonly there is true stratification of the abnormal epithelial cells and, occasionally, intraglandular budding. In the smaller tumor the atypical glands extend downward to interrupt the muscularis mucosae. In the larger tumor the invasion is much more evident. The atypical glands have infiltrated the submucosa and extend through the muscularis into the subserosal fat. A lymph node in the subjacent fat is free from tumor. However, the submucosal veins and lymphatics not only beneath the tumor but also beneath the contiguous normal mucous membrane are filled with neoplastic cells. In the smaller tumor there is a slight increase in the amount of the submucosal connective tissue which is relatively dense. The larger tumor shows a much greater increase in the amount of connective tissue and the density varies in different fields. In most fields where the tumor has infiltrated, the desmoplastic quality of the tumor is demonstrated. Both of these tumors have in common many abnormal histologic and cytologic changes. In the smaller tumor the degree of invasion is slight, but in the larger tumor it is unquestionable. It seems logical, therefore, in view of the common cytologic and histologic alterations, to regard both tumors as carcinomas. Moreover, it seems fair to consider the incipient invasion present in the smaller tumor as the initial stage in the development of unquestioned invasion. In neither carcinoma was it possible to demonstrate the structure of an adenoma. It is conceivable that a pedunculated adenoma with malignant transition existed at one time and subsequently became torn from its attachment to the colon by peristaltic action. However, in the absence of such proof it seems reasonable to conclude that these two carcinomas arose directly from the mucosa and not through the evolution of an adenoma.

In brief then, small or histologic carcinoma of the large intestine occurred in 12 of the 1,460 patients in this series. On the basis of the evolution of these carcinomas, the patients can be divided into two groups.

In the first group are those patients in whom the carcinoma developed in an adenoma. There were 10 patients with tumors of this type. In 8 of these 10, the large intestine contained a single tumor, one intestine contained two tumors and another, three tumors. Three of the 10 large intestines with carcinoma present in an adenoma also showed an obvious or manifest carcinoma, and all but 2 contained benign adenomas elsewhere in the large intestine.

In the second group are those patients in whom the carcinoma developed direct from the mucosa and not in an adenoma. There were 2 patients with tumors of this type. In both instances the carcinomas were single lesions and in neither instance were there adenomas or carcinomas elsewhere in the large intestine.

When both groups are considered together, 4 of the 12 large intestines presented solitary tumors. In 2 cases the tumor was a carcinoma arising in an adenoma and in 2, a carcinoma arising direct from the mucous membrane. The large intestine of each of the remaining 8 patients contained at least one instance of a carcinoma arising in an adenoma and, in addition, either benign adenomas, a manifest carcinoma or both. In the study of 25 patients with manifest carcinoma in this series, there were either benign adenomas or adenomas with malignant transition present elsewhere in the large intestine in 13 instances. In the other 12 intestines a carcinoma was the only tumor present. Thus, both in the group of histologic carcinomas and in the group of manifest carcinomas there were other tumors of glandular origin present in over 50 per cent. The group of 12 small or histologic carcinomas does not constitute a large number of cases. Of the 12 patients, the carcinomas in 10 arose in an adenoma and in the other 2 arose direct

from the mucous membrane. If this small group is representative of the evolution of carcinoma of the large intestine in general, then the majority of carcinomas of the large intestine develop in adenomas.

SUMMARY AND CONCLUSIONS

1. Adenomas of the large intestine are true neoplasms and not a reaction consequent to a diffuse inflammatory process.

2. The incidence of adenomas of the large intestine increases with age. An appreciable increase in the incidence begins in the fourth decade and reaches a maximum (24 per cent) in the eighth decade.

3. Adenomas are more common in the white race than in the negro race.

4. Adenomas are slightly more frequent in men than in women in all sites of the large intestine.

5. In the series here reported on, 58 per cent of the patients with adenomas had single tumors. Single adenomas are more common in women (63 per cent) than in men (55 per cent).

6. Multiple adenomas are as common in the fourth decade as in the eighth decade of life in those patients who have adenomas.

7. Inflammation, hemorrhage and hemosiderin are commonly observed in the larger adenomas.

8. The incidence and distribution of adenomas of the large intestine have been carefully determined in 1,460 consecutive autopsies. Histologic evidence and cytologic evidence have been presented to the effect that adenomas of the large intestine undergo malignant transition.

9. Collateral evidence of the intimate relation of adenomas to carcinomas of large intestine is cited. In this series both adenoma with malignant transition and manifest or unquestioned carcinoma are more common in the older age groups. Likewise, both adenoma with malignant transition and unquestioned carcinoma show similar sites of predilection in the large intestine.

10. Two carcinomas arising directly from the mucous membrane are described.

11. Some carcinomas of the large intestine arise directly from the mucous membrane but the majority develop in adenomas.

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SURGICAL FUSION OF THE VERTEBRAL ARTICULAR FACETS: TECHNIQUE AND INSTRUMENTS EMPLOYED

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COMPLETE bony fusion of the vertebral articular facets prevents motion of the spinal column. When these facets are fused by surgical methods and the added support of massive bone grafts is employed, fixation of great strength results. In previous publications (1, 3) I have illustrated the method I employed in producing adequate strength in the fused areas to withstand the stress and strain on the spinal column in action. In the past 3 years I have designed several new instruments (4) and improved the technique of fusion of the facets sufficiently to make it appear advisable to describe the method now employed. It has been obvious that there is considerable interest in this method and the results obtained from it.

In the past I have employed fusion of the intervertebral articular facets in addition to massive autogenous bone grafts with excellent results. It is now my belief that a thorough bony fusion of the intervertebral articular facets themselves may provide adequate fixation.

By far the greatest difficulty encountered in fusion of the facets results from inadequate exposure of the parts to be fused. In order that the surgeon may see the facets, the incision should be ample, the spinous processes and laminae thoroughly denuded, and the erector spinae muscles retracted laterally. Many retractors have a tendency to slip from the muscles and, if this occurs, it is impossible to gain access to the articular facet. Therefore, retractors of varying widths have been designed which are deep enough to reach into the depths of the wound easily; the retractor edges have short teeth bent toward the handle (Fig. 1). With such instruments it is possible to grasp the tissues, capsule, and muscle and retract them laterally, well away from the lamina and maintain exposure of the facet.

It is not always easy to recognize the articular facets even when they are exposed prop-

From the Section on Orthopedic Surgery, Mayo Clinic.

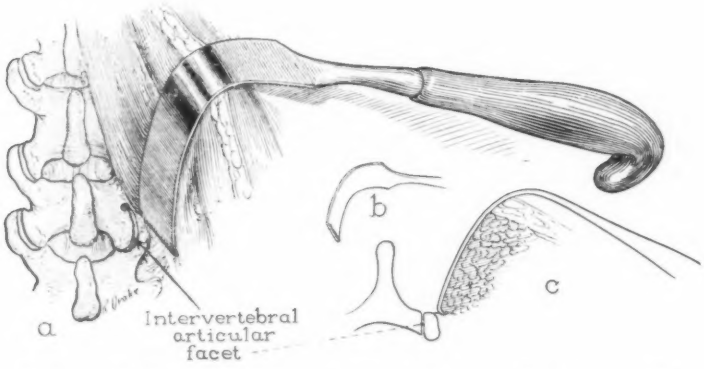

Fig. 1. *a*, Newly designed laminectomy retractor demonstrating exposure of intervertebral articular facet. *b*, Retractor showing toothed edge. *c*, Interarticular facet exposed by retraction of the capsule and muscles, laterally.

erly, for the articular spaces are narrow and sometimes are placed well laterally. The joints may be demonstrated by moving the spinous processes of the vertebrae with a forceps, thus disclosing the gliding articular surfaces. When the joints have been identified, a sharp chisel is used to scrape the laminae from the bases of the spinous processes outward; this scraping turns up small shavings of bone and destroys the capsules and the posterior portions of the intra-articular facets. This first stage of the operation may be sufficient in many cases to produce fusion of the facets and it was the method which was formerly employed.

The facets are true articular surfaces and it is wise to destroy them to obtain thorough bony fusion of the joint. It is necessary to have a narrow instrument to accomplish this and I formerly used a small curette. I have designed and now use a narrow chisel or a specially made sawlike eroder. No matter what type of instrument is used, the cutting end absolutely must be controlled lest there be injury to the nerve tissues.

I have found a narrow bladed chisel, 1/16 inch by 10 inches (0.16 by 25.4 cm.) and strong enough to withstand the force required to enter the articular interspace (Fig. 2*a*), of considerable value in eroding the articular surfaces. To erode the facets the chisel is dug into the joint interspace, and the débris is forced forward and outward as illustrated in Figure 2*b*. Bone chips then can be forced downward into the eroded interspace as shown in Figure 2*c*.

Recently I designed a small curved toothed saw which can be used to erode the articular surfaces of the facets even more efficiently than can the chisel (Fig. 3). The teeth are offset and the cutting edge is curved slightly. When the saw is turned slightly in the joint and is dragged toward the surgeon, it is found that the erosion of a facet is accomplished in a few strokes (Fig. 4). The instrument has a large enough handle so that it permits absolute control of the cutting edge by the surgeon.

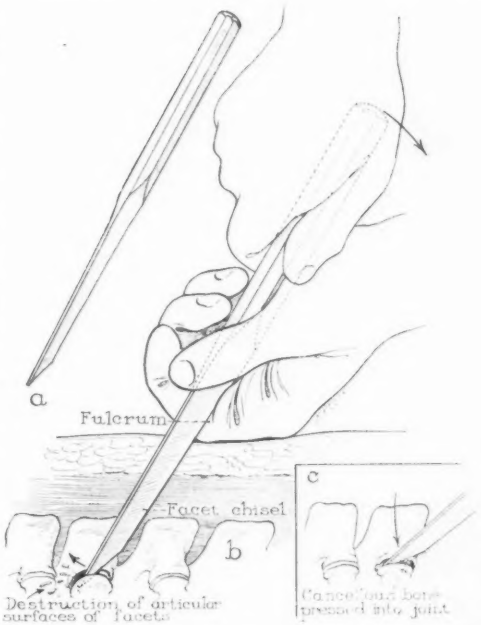

Fig. 2. *a*, Narrow chisel, 10 inches (25.4 cm.) long and 1/16 inch (0.16 cm.) wide. *b*, Chisel being used to destroy joint surfaces of vertebral articular facets. *c*, Chisel forcing bone chips into the eroded interspace.

Erosion of the articular surfaces is carried out bilaterally throughout the part of the spinal column that is to be fused. The bone shavings which were turned from the laminae and cancellous bone from the tibia then are forced into and piled about the destroyed facets. When the muscles are allowed to relax they cover the region and tend to hold the fragments of bone in position and a mass of new bone forms. When the procedure which has just been described is carried out, firm fusion results. When it is employed in addition to massive bone grafts, it materially aids in the success of producing fusion of great strength (Fig. 5, left and right).

Fig. 3. Bone saw facet eroder, 10 inches (25.4 cm.) in length. Teeth are offset so as to cut a groove 1/16 inch (0.16 cm.) in width.

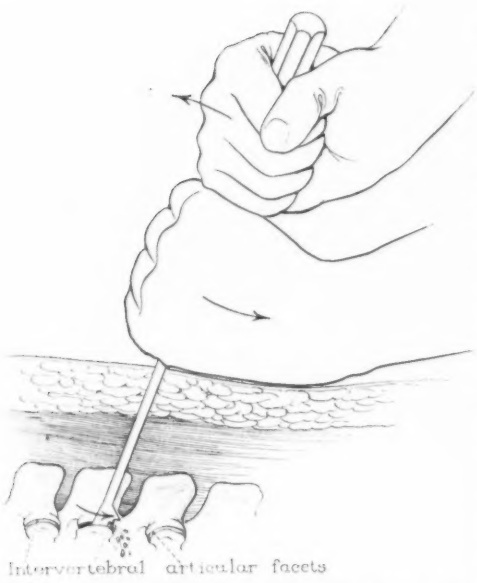

Fig. 4. Bone saw facet eroder inserted into the vertebral articular facet and cutting out the joint surfaces.

REPORT OF CASES

CASE 1. A nurse, 40 years of age, came to the Mayo Clinic because of intermittent low back pain of about 20 years' duration. Coughing, sneezing, lifting, and stooping aggravated the pain and left sciatic pain developed and persisted for 6 months. Because of the pain it became necessary for her to give up nursing about 3½ years before admission and do clerical work. In the 4 months prior to her admission symptoms became more severe.

On examination the patient was found to be a well developed and well nourished woman with limitation of forward and lateral bending of the spinal column. The knee and ankle reflexes were normal. Roentgenologic examination disclosed narrowing of the fourth and fifth and lumbosacral interspaces with hypertrophic changes, some lumbar scoliosis and a slight defect due to spina bifida at the first sacral vertebra (Fig. 6). The history and examination suggested the possibility of protruded intervertebral disc. A spinogram showed slight posterior displacement of the air column opposite the fourth lumbar interspace consistent with protrusion of an intervertebral disc at this level. The consulting neurosurgeon and orthopedist conferred and decided to perform laminectomy to explore the fourth and fifth lumbar interspaces for a possible protrusion of the intervertebral discs and if necessary to fuse the third, fourth, and fifth lumbar vertebrae and sacrum.

Operation was performed on July 20, 1945. Partial laminectomy and decompression of the cauda equina with bilateral resection of the fourth and fifth lumbar ligamenta flava were performed. The findings at the fifth lumbar interspace were not abnormal. At the fourth lumbar interspace the ligament was abnormally thickened and the nerve root was more hyperirritable on the left side than on the right. The partial laminectomy thoroughly unroofed the hyperirritable nerve roots. A distinct ridge of bone extended across the fourth interspace but the intervertebral disc was not protruded. Then the spinous processes and laminae of the third, fourth, and fifth lumbar vertebrae and upper two segments of the sacrum were scarified, bilateral fusion of the interarticular facets was performed and bone grafts were inserted on each side. Bone chips and cancellous

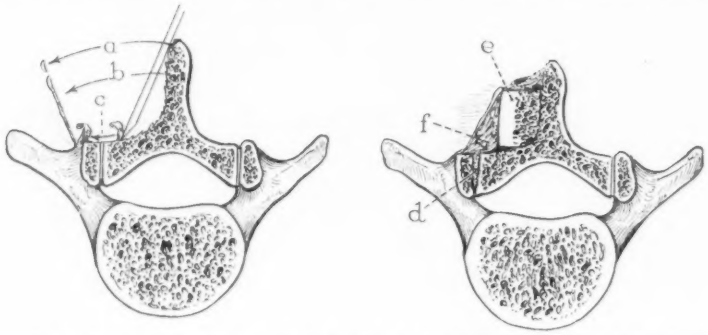

Fig. 5. Left, *a* and *b*, Tip and lateral portion of spinous process chiseled off and displaced laterally. Chisel turning bone chips laterally from the lamina and eroding the facet posteriorly. *c*, Facet exposed. Right, *d*, Eroded facet with bone chips inserted. *e*, The bone graft with cancellous portion of bone against roughened surface of the spinous process and lamina; small bone chips inserted about the graft. *f*, Multiple bone chips packed above facet and between the bone graft and displaced fragment of spinous process.

Fig. 6.

Fig. 7.

Fig. 8.

Fig. 6. Case 1. Anteroposterior view. Rotation has brought out the facets on the right side.

Fig. 7. Case 1. Postoperative anteroposterior roentgenogram view 8 months later.

Fig. 8. Case 1. Lateral view showing firm fusion of the graft which extends well down on the sacrum.

Fig. 9.

Fig. 10.

Fig. 11.

Fig. 9. Case 2. Anteroposterior view of the spinal column and pelvis discloses a congenital large spina bifida occulta involving the fifth lumbar and first sacral vertebrae, and spondylolisthesis, grade 2 of the fifth lumbar vertebra on the sacrum with separation of the neural arch.

Fig. 10. Case 2. Anteroposterior view of lumbar portion of the spinal column and pelvis 5½ months after operation. Double bone grafts have fused the third, fourth, and fifth lumbar vertebrae. Grafts extend down onto the upper segments of the sacrum, bridging the spina bifida occulta of the fifth lumbar and first sacral vertebrae. The facets have been fused as shown in this roentgenogram.

Fig. 11. Case 2. Lateral view 5½ months after operation showing the spondylolisthesis of the fifth lumbar vertebra on the sacrum. The bone graft covers third, fourth, and fifth lumbar vertebrae and upper half of sacrum.

bone obtained from the tibia were packed at the ends and under the grafts to make better contact.

Convalescence was uneventful and the patient was dismissed from the hospital on the thirtieth postoperative day, at which time she was wearing a lumbosacral corset. She returned to her home physician for further observation.

The patient returned to the Clinic 8 months after operation. She stated that she felt better than at any time in the past 20 years. She had gained 8 pounds (3.6 kgm.) and had no backache. Roentgenograms showed that firm fusion of the bone grafts and fusion of the articular facets had occurred (Figs. 7 and 8).

CASE 2. The patient registered at the Mayo Clinic for the first time in 1940 when appendectomy was performed. He complained of backache and pain in the right hip of 2 years' duration and a diagnosis of spondylolisthesis was made at that time.

The patient was seen again at the Clinic in June, 1945, and in spite of the use of a lumbosacral support and other conservative treatment he still complained of backache and of pain in the left hip. These symptoms were aggravated by standing and the pain was projected to the calf of the left leg. It was suspected that possibly a protruded intervertebral disc complicated spondylolisthesis (2). Roentgenograms disclosed spondylolisthesis, grade 2 (on a grading basis of 1 to 4 in which 1 represents the mildest and 4, the most severe form), of the fifth lumbar vertebra on the sacrum, separation of the neural arch and a large spina bifida occulta involving the fifth lumbar vertebra and the sacrum (Fig. 9). Following neurologic and orthopedic consultation a combined operation was recommended. The neurologic surgeon explored the fourth and fifth lumbar interspaces after left laminectomy. Nothing abnormal was observed. Bone grafts were inserted on each side to include the third, fourth, and fifth lumbar vertebrae and sacrum; the facets of the third, fourth and lumbosacral vertebrae were fused and multiple bone chips were inserted about the grafts.

The patient left the hospital on the twenty-eighth postoperative day. At that time he was able to walk, and the wounds were healed and in good condition. This patient was seen 5½ months later when he drove his automobile from his home community to Rochester for physical examination. Roentgenograms showed that the bone grafts were firmly fused (Figs. 10 and 11) and the facets were fused. He was advised to return gradually to further activity.

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AXILLARY APPROACH TO SCHEDE THORACOPLASTY

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IN the treatment of chronic empyema, Schede thoracoplasty has been utilized for those infections in which the visceral pleura has failed to re-expand sufficiently to approximate the parietal pleura and in which the parietal pleura has been sufficiently rigid to prevent its approximation to visceral pleura. Schede thoracoplasty consists of mass excision of chest wall including thickened parietal pleura, ribs, rib beds, intercostal muscles, nerves, and vessels overlying the extent of the infected space to allow the fresh extrathoracic muscle tissues to fall in and obliterate the infected space.

As originally described by Schede and the earlier writers, the posterior approach was advocated to visualize the ribs overlying the cavity. Through a paravertebral right angle or hockey stick incision the trapezius and rhomboid muscles were divided posteriorly and the incision continued laterally around the tip of the scapula and brought forward dividing the latissimus dorsi posteriorly. The scapula was then retracted anteriorly and the ribs, parietal pleura, and intercostal muscles resected posteriorly and as far forward as the space extended, to unroof the cavity. Following this the scapula and extrathoracic muscles fell in to fill the space previously covered with parietal pleura.

Employment of the posterior approach for Schede thoracoplasty is accompanied by complications of wound healing and infection that become apparent in any experience with the operation. If the posterior wound which is exposed to infection is closed tight, any movement of the scapula will tend to reopen the wound or weaken the suture line to cause sinus formation with possible breakdown of the entire wound from the adjacent infection beneath. Similarly, the latissimus dorsi muscle, which must be divided and exposed to infection, will as a result, atrophy below the incision and will form a much less healthy muscle for muscle graft at a later date. If the entire wound is packed and not closed, the scapula will remain as a movable bone separated from its muscular attachments posteriorly. Between this bone and the spine will remain a sinus or groove of infection which must heal before the space can be obliterated. Also the wound, as estimated by the exposed surface, is sizable, and healing will take a correspondingly long time.

Such complications have been largely eliminated since the axillary approach to Schede thoracoplasty has been employed. The incision is so placed that pectoralis major and latissimus dorsi muscles are both preserved without impairment of blood supply. After the vertical incision has been made in the midaxillary line, these muscles are retracted anteriorly and posteriorly on either side of the incision so that both anterior and posterior segments of ribs are easily reached. The chest wall to be removed is excised from below upward beginning at the diaphragm, if the empyema is a complete one, and proceeding toward the apex of the pleural cavity. The approach to the pleural space is direct with minimal damage to extrathoracic muscles which may be useful later for muscle implantation. The incision itself is smaller, and there is not the large residual wound that occurs when posterior paravertebral hockey stick approach is used. Motion of the scapula postoperatively has little tendency to open the wound, nor does infection tend to burrow beneath the scapula to form sinuses that may develop in the posterior approach after the wound is sewed up. Drainage ideally is placed directly in the center of the wound in the midaxillary line and will be dependent for the space that is being unroofed.

When preliminary thoracotomy is necessary in chronic empyema it should be performed through the midaxillary line at the most dependent portion of the pleural space. If the empyema is complete, drainage is made at the junction of the diaphragm with chest wall.

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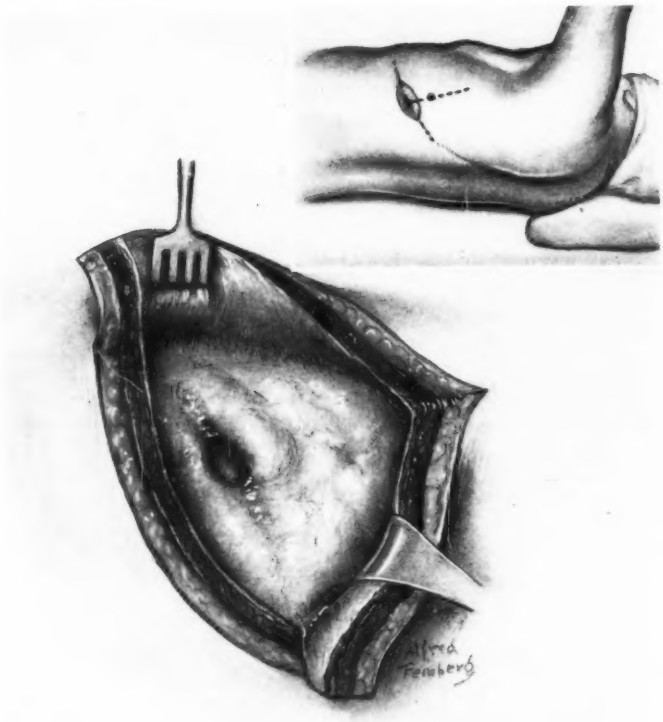

Fig. 1. Insert shows patient placed on the operating table with the arm elevated and suspended for an axillary approach to the chronic empyema. The tube has been removed from the lower thoracotomy opening which was placed at the most dependent site of the empyema cavity in the midaxillary line. The small opening above the thoracotomy opening represents a sinus at the site of the previous empyema necessitatis. T-shaped incision for the first stage Schede thoracoplasty operation is made at the dotted line extending toward the extrapleural thoracoplasty scar posteriorly.

Main picture shows T incision deepened to separate the pectoralis major from the latissimus dorsi muscles in the midaxillary line. The thoracotomy opening into the pleural space is shown extending through the plaque of regenerated ribs which has formed since previous extrapleural thoracoplasty.

Such drainage is so placed as to allow easy access to the pleural space at the time of Schede operation and to preserve musculature posteriorly. Thoracotomy is performed with removal of segments of two ribs; underlying parietal pleura, intercostal muscle, and rib bed are excised to allow a large opening. Thus if delay in the Schede thoracoplasty occurs, the thoracotomy opening will remain adequate in spite of the tendency of the chest wall to contract with closure of the opening. Removal of the rib bed minimizes regeneration of rib at thoracotomy site and simplifies the initial step later in Schede procedure.

At a suitable date following, Schede thoracoplasty is performed with the patient lying on the good side with the affected side up, and arm abducted and elevated over the head. The arm is suspended by means of a bar over the patient's head, which exposes the axilla and retracts the axillary vessels upward to allow easy access to the apex of pleural cavity.

A transverse incision is then made at the base of the pleural space to include the thora-

Fig. 2.

Fig. 3.

Fig. 2. Beneath the thoracotomy opening the 10th rib has been resected as have the costal cartilages of the 9th, 8th, and 7th ribs anteriorly. Dotted line outlines the limits of the underlying pleural space that is to be unroofed at this stage operation. Note that the costal cartilages have been removed an inch beyond the extent of the pleural space to allow gradual falling in of the tissues adjacent to the pleural space.

Fig. 3. Dotted line outlines the plaque of regenerated ribs, parietal pleura, and intercostal muscles that is to be removed at first stage operation. This is best performed with double action rib cutter and blunt scissors. Sharp rake retractor or hook will control the tissue to be removed, which in some cases may be over 2 inches in thickness.

Fig. 4. Pleural plaque is divided anteriorly and posteriorly, care being taken to clamp intercostal vessels posteriorly as they are encountered to avoid unnecessary hemorrhage. Anterior vessels usually do not bleed sufficiently to require hemostasis. Forming the base of the saucerized space are the diaphragm below, the pericardial pleura anteriorly and collapsed lung covered by visceral pleura extending upward from the diaphragm. Note anteriorly the small edge of parietal pleura at the re-entrant angle of pericardium with chest wall which has been removed in Figure 5 to allow even approximation of tissues.

cotomy opening. The ribs beneath the opening into the pleural space are removed subperiosteally. These may lie horizontally, in which case it may be necessary to remove only one rib. Usually, however, the ribs are situated more vertically so that segments of several must be removed to allow the tissues immediately beneath the thoracotomy opening to fall in gradually. With the finger in the drainage opening, it is possible to outline exactly where the parietal pleura, intercostal muscles, and

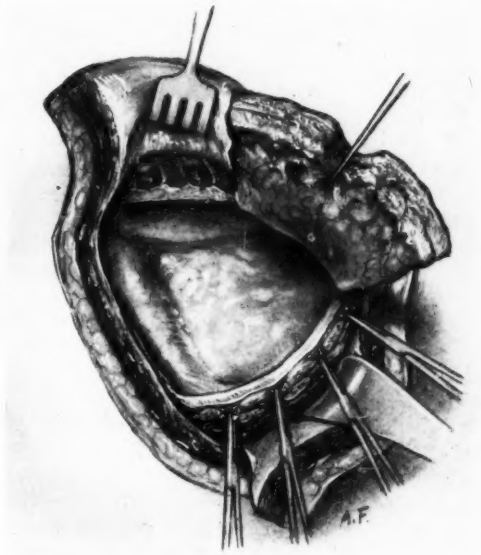

Fig. 4.

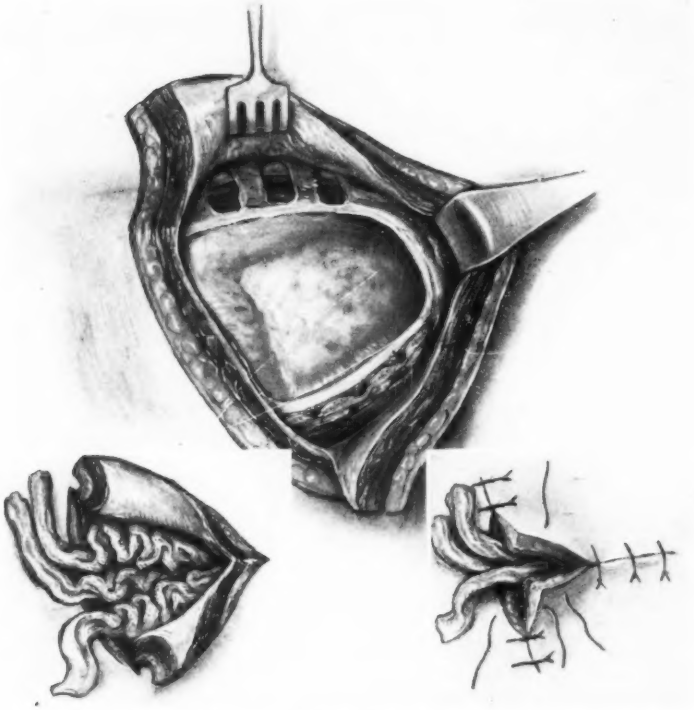

Fig. 5. The bevelled edge of parietal pleura is clearly demonstrated anteriorly and posteriorly. The remainder of the chest wall is left for the next stage of the operation. Packing placed in the pleural space walls off the freshly divided muscle planes and prevents extension of infection into newly exposed tissues. A few through-and-through stitches are sufficient to approximate the tissues and minimize the external wound surface.

rib beds are to be resected and to judge accordingly how far the ribs overlying solid tissue should also be removed.

A vertical arm is then extended upward in the midaxillary line toward the apex of the axilla. This is deepened down to the ribs underneath, dividing serratus anterior fibers and the axillary tissues to separate the pectoralis major anteriorly from the latissimus dorsi posteriorly. The tissues on either side of the incision are then retracted to expose the underlying ribs without damage to the muscles. With the index finger in the drainage site the outline of the pleural cavity is again defined, and small segments of ribs are removed anteriorly and posteriorly at the re-entrant angle of the parietal pleura beneath. After such segments are resected, the large piece of chest wall is then removed with the help of large blunt scissors extending upward as far as is feasible without change in the patient's condition. Care must be taken during this part of the procedure to clamp the intercostal vessels posteriorly as they are met. A straight Kocher clamp is best utilized for this purpose. If these are not applied until the tissue is removed, the patient will have lost a considerable amount of blood, which can be avoided by immediate application of the clamps. Not only should the ribs be removed beyond the limits of the empyema space but the parietal pleura should be leveled so that no ledge of tissue remains to form a groove and prevent approximation of fresh tissues with underlying visceral pleura.

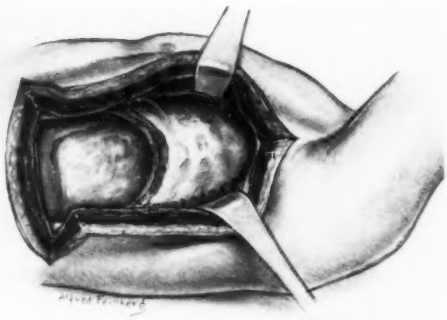

Fig. 6. The ease of approach is clearly shown in this picture. At the second stage operation the wound is reopened and the axillary arm of the incision extended upward toward the apex of the pleural space. Dotted line represents the tissue to be removed overlying collapsed lung. Pectoralis major and latissimus dorsi muscles have been preserved and are retracted on either side.

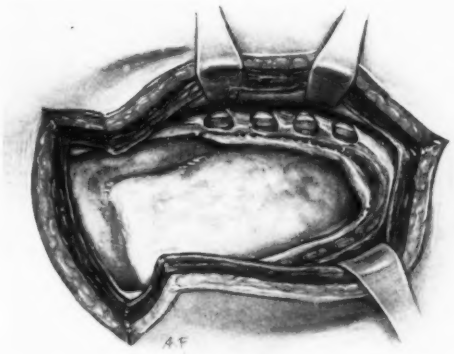

Fig. 7. Segments of ribs again are removed anteriorly beyond attachment of visceral pleura to chest wall. Bleeders are clamped and tied posteriorly as they are encountered. Overlying ledge of parietal pleura must be excised as failure to do this is frequent cause of persistence of residual space.

In cases in which an extrapleural thoracoplasty has been performed before starting the Schede procedure, the regenerated ribs and rib beds overlying the pleural space will consist of a rarefied mass of bone that has become confluent to form an irregularly solid bony plaque. In the past the Schede operation used to be performed by an attempt first to remove the regenerated plaque from the underlying periosteum and parietal pleura which was followed, if necessary, by resection of the thickened pleura. As the pleura almost always had eventually to be removed, and in order to avoid the formidable bleeding that is encountered in that procedure, initial resection is now employed to excise the chest wall *en masse* without any attempt first being made to separate regenerated bones from parietal pleura.

As in the operation where extrapleural thoracoplasty has not been first employed, the extent of the pleural space is estimated with the finger in the drainage site; and ribs, pleura, bony plaque, and intercostal muscles are divided with the rib cutter and blunt scissors. Difficulty may be encountered in visualizing the tissues during this operation. The superficial chest wall muscles should therefore be separated by sharp dissection from their attachments to the regenerated ribs, during which procedure almost no bleeding will be encountered. A sharp rake retractor may then be hooked into the pleural mass which will control the tissue and allow the operator to visualize the intercostal bleeders as they are encountered. Again, importance is laid on immediate clamping of these vessels as they will not stop bleeding on removal of adjacent bone.

As in any serious operation on a debilitated patient, constant attention should be paid to the general condition of the patient during the operative procedure. In the Schede operation the best index of the patient's condition is the pulse. A sharp rise of pulse even without corresponding fall in blood pressure should suggest to the operator an early termination of the operation. The operation itself should never be performed without ample amounts of blood, frequently as much as 1500 to 2500 cubic centimeters of blood being given at a single stage operation. A gradual rise of pulse during the operation indicates a pause in the operative procedure while more blood can be administered and the patient's condition improved. Occasionally a patient's pulse is rapid before the operation is begun. In such cases blood should be running into the patient's veins before any incision is made and, provided the pulse remains elevated, a very small amount of surgery should be attempted at that stage. Thus the operator is in constant touch with the anesthetist and can judge the amount of surgery to which the patient is to be subjected.

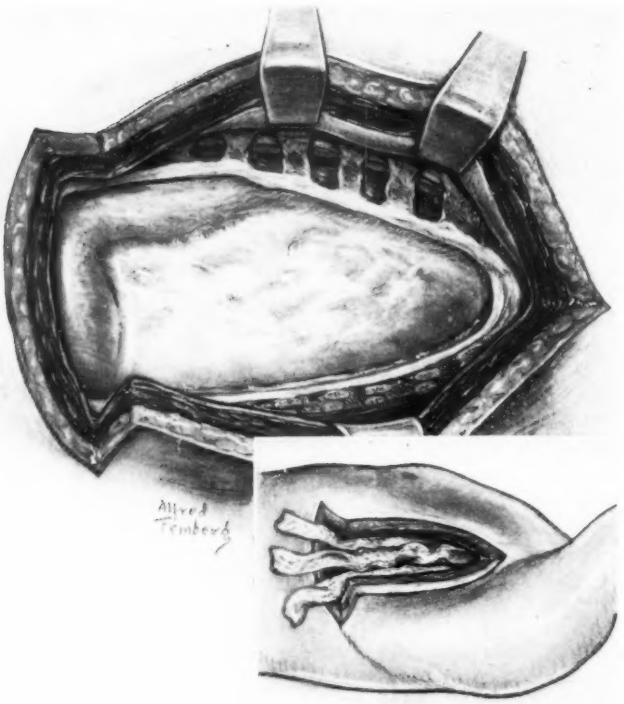

Fig. 8. Final stage of the procedure shows completed operation with parietal pleura, intercostal muscles, vessels, nerves, and ribs removed to unroof the underlying infected pleural space. Bevelling of parietal pleura is shown up to the apex for even approximation of tissues. Packing will be removed after tissue planes are walled off and allow extrathoracic tissues to fall in on the visceral pleura of collapsed lung and obliterate the empyema space.

It usually requires two operations before a complete removal of chest wall can be effected, although as many as six or more have been performed in patients in extremely poor condition. Since the procedure has been staged, severe postoperative reactions have been minimized and mortality markedly diminished. In earlier cases when the blood pressure was used as an indicator of the amount of surgery that should be given a patient, the patient's condition seemed satisfactory on leaving the operating table but was soon followed by a state of deep shock from which it was difficult to arouse the patient.

Patients with chronic empyema of any standing are notably debilitated. Not only are they underweight, chronically ill, and with a tendency to be anemic, but also they show a lack of normal blood volume which may account in large part for their inability to stand surgery of any degree. Individual patients will differ in this regard, however, and without careful studies it is difficult to predict in advance the response an individual will show. The importance of bearing in mind the various factors that may influence the patient's condition cannot be overemphasized, as the amount of surgery that is performed will always depend in large measure on how much the patient can stand.

Finally, axillary approach is well adapted for quick closure when it is necessary to terminate the operation. In contrast with the axillary wound the posterior approach must be

sutured in layers in order to effect tight closure. This step requires more time and must be considered in estimating the amount of surgery that can be performed.

Three or four through-and-through sutures will approximate the axillary wound at its upper limit. Gauze packing is placed next all freshly divided tissue planes to stimulate a reaction in the tissues and to prevent extension of the infection. This packing is brought out through the dependent part of the wound and can be removed on the fifth to the seventh days. At this time when the gauze is removed the extrathoracic tissues will fall in and adhere to the collapsed visceral pleura beneath.

SUMMARY

1. The technique of Schede thoracoplasty using the axillary approach is described.

2. The advantages of this approach over the posterior paravertebral hockey stick incision are emphasized, notable among which are ease of approach and closure of wound, preservation of extrathoracic musculature, avoidance of infection and postoperative complications of wound healing.

A HEMORRHOIDECTOMY ELIMINATING THE USE OF THE CLAMP

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A SATISFACTORY hemorrhoidectomy must remove all the hemorrhoids and redundant tissues. With certain obvious reservations, any type of operation which achieves a desirable end-result is adequate. Operations involving the use of the hemorrhoid clamp are suitable in some instances. However, it is technically difficult or sometimes impossible to manipulate the clamp so as properly to cope with cases in which hemorrhoids and redundant mucosa must be resected high above the pectinate line. Some other types of hemorrhoidectomy designed to eliminate the hemorrhoidal clamp are not completely satisfactory because of failure to achieve proper fixation of the rectal mucosa, inadequate control of mucosal bleeding, or the tendency of the ligature to slip.

Following, is a description of an operation eliminating the hemorrhoidal clamp. Under sacrocaudal or low spinal anesthesia, with the patient in the jack-knife position, the buttocks are retracted laterally and held by means of broad strips of adhesive tape fixed to the operating table. Having thus obtained adequate exposure, appropriate preoperative preparation and draping are carried out. At this point 6 cubic centimeters of 1 per cent diothane solution is injected into the sphincter muscle for the purpose of controlling postoperative pain. Using the finger as a guide, a 2 inch, 22 gauge needle is introduced into the posterior midline just outside the anal verge. Two cubic centimeters of the solution is injected into the muscle at this site. The needle is partially withdrawn and reinserted in a right anterolateral direction. Two cubic centimeters of the solution is placed in the lateral quadrant of the muscle on this side. In the same manner the needle is again partially withdrawn and the rest of the anesthetic is injected into the left lateral quadrant of the muscle. It is felt that the logical time for this procedure is preoperatively rather than postoperatively because the soiling which necessarily results from a rectal operation increases the possibility of abscess formation following injections in this region.

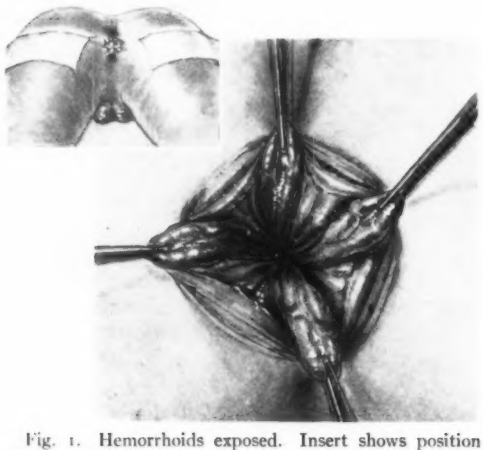

Fig. 1. Hemorrhoids exposed. Insert shows position used for operation.

After careful dilatation, retracting clamps are applied to the margins of the anus and these are drawn apart. The hemorrhoidal masses are now grasped and exposed. In this manner the hemorrhoids are demonstrated and the degree of deformity is evaluated (Fig. 1). The skin adjacent to one of the hemorrhoidal masses is grasped by a straight hemostat which is pulled in the direction away from the anus and held by an assistant. A second hemostat is fastened to the skin just inside the first and upward traction is exerted on this by the operator. With the skin thus placed under moderate tension, an elliptical incision is commenced on the skin between the two hemostats which includes hemorrhoid and redundant mucosa (Fig. 2). The hemorrhoidal mass outlined by the incision is dissected free from the external sphinter muscle and underlying tissues from below upward. Dissection is fa-

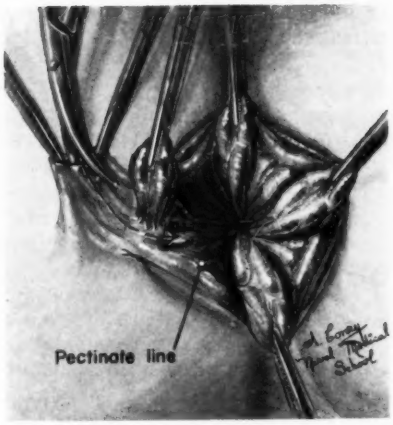

Fig. 2. Beginning the dissection of the hemorrhoidal mass.

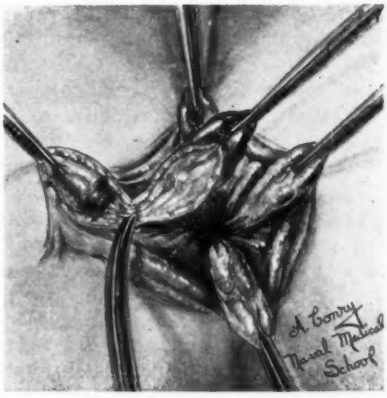

Fig. 3. Dissection complete.

cilitated by maintenance of tension on the hemostats and the use of curved dissecting scissors. When the dissection has been completed, the hemorrhoidal mass remains attached by a relatively narrow pedicle of mucosa (Fig. 3).

A ligature of No. 1 plain catgut is fixed in the following manner. The dissected hemorrhoidal mass is drawn away so as to expose the upper extremity of the line of incision on the side of the operator. The mucosa above the apex of the incision is included by a mattress suture. The ligature is now brought through the base of the pedicle on the same side. Next, the superficial fibers of the internal border of the external sphincter muscle are included. The ligature is brought back through the base of the pedicle on the opposite side. Now, the hemorrhoidal mass is drawn in the other direction so as to expose the upper extremity of the incision on the side away from the operator. A mattress suture is placed in the mucosa above the apex of the incision on this side which completes the ligature. The suture is tied securely and the hemorrhoidal mass distal to the tie is amputated. Each of the hemorrhoidal masses is dissected, ligated and cut in the manner described. All bleeding points in the denuded areas are caught and tied. The stumps are carefully checked for bleeding by exposing each with a Smith rectal speculum. A thin strip of vaseline gauze or rubber dam is inserted in the anus for drainage. A dressing consisting of a small piece of gauze is laid over the anus. This dressing will remain in place without the aid of adhesive strips or a T binder. No other postoperative dressing is required.

The postoperative care is relatively simple and uncomplicated. When sensation returns, continuous hot packs are applied locally and liberal doses of morphine or pantopon are given to control the pain. A regular diet is allowed on the day of operation. The drain is removed the day following operation. Hot

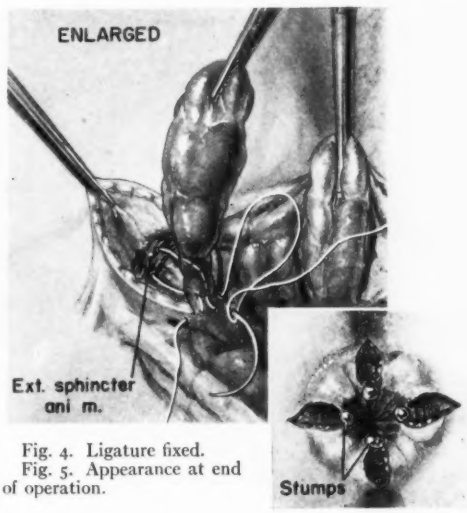

Fig. 4. Ligature fixed.
Fig. 5. Appearance at end of operation.

packs are now discontinued and warm sitz baths are commenced three times daily. After each bath the raw areas are carefully swabbed with a cotton applicator soaked in 15 per cent alcohol following which, a small piece of dry cotton is laid across the anus. No other dressing or appliance is required. The patient becomes fully ambulatory after the first day. No attempt is made to prevent early bowel movement; the patient is encouraged to move the bowels after the first day. Laxatives are not allowed but a low tap water enema is given on the third postoperative day if the bowels have not moved by that time and every 2 days thereafter until the patient has daily unaided evacuations. Under this treatment a regular bowel habit is soon developed regardless of a previous history of the promiscuous use of laxatives or chronic constipation. Digital dilatations are unnecessary because the daily dilatation produced by a formed stool is quite effective and considerably more comfortable for the patient to endure.

This type of hemorrhoidectomy presents several advantages. It is technically simple and may be used successfully for practically all types of hemorrhoids encountered. The hemorrhoid clamp is entirely eliminated. All the hemorrhoids and redundant tissues can be removed even though it may be necessary to dissect high above the pectinate line. Because of the several points of fixation, the mucosa has no tendency to slip out of the grasp of the ligature. Bleeding is adequately controlled and the mucosa is well gathered in and drawn down where it is securely fixed at about the level of the pectinate line. Comparatively little raw surface remains a fact which makes the tendency toward stricture formation negligible.

The author has used this type of operation in 800 cases with excellent results.

SURGICAL CORRECTION OF NASAL DEFORMITIES

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THE nose is the most prominent feature of the face. Real or fancied nasal deformities have a high priority in the consciousness of the owner as well as the observer and cause many patients to seek correction.

Most corrections of nasal appearance depend upon shifting the interrelationship of the component parts of the nose, or changing their size and shape, and a good understanding of the rôle of the anatomical parts in supplying the framework to the external nose is necessary before undertaking any such correction.

The upper third of the external nose is supported by the nasal bones and the adjacent frontal processes of the maxillae; in the middle third are the paired upper lateral cartilages, which are continuations of the nasal bones and like the nasal bones are fused with the septum in the midline (Figs. 1 and 2). Consequently, both nasal bones and upper lateral cartilages in addition to forming the side wall of the nose have an important rôle in supporting the dorsum and forming a part of the profile line. Inferior to the upper lateral cartilages are the paired alar cartilages, comprising for the most part the skeletal framework of the tip. These alar cartilages are more or less free floating (Fig. 3). They are not intimately adherent to the upper lateral cartilages as the latter are to the nasal bones. Although they are adjacent to the septal cartilage they are not attached to it as are the upper laterals. Thus the alar cartilages and their continuation into the columella supply a framework which gives bulk and shape to the tip of the nose, as well as height. However, as supporting structures, they depend on relatively loose attachments to the upper lateral and septal cartilages through the medium of soft tissues (Fig. 2). This relationship must be remembered, especially in dealing with problems in which septal support to the lower portion of the nose has been lost.

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The cartilaginous septum is the ridgepole which gives height to the lower two-thirds of the nose, supplies support to the other cartilaginous structures, and oftentimes causes a shifting from the midline of the external nose when it has been displaced by trauma (Figs. 17 and 18). The septum is the one structure most often deformed and the one interfering with the function of the internal nose.

The external nose is covered with skin and an areolar type of subcutaneous tissue. The quality of this soft tissue covering differs in the upper and lower portions. Over the nasal bones the skin is thin; the subcutaneous tissue is scant in amount. The glandular structures are not as well developed or active as in the lower portion. At the tip of the nose the skin is palpably thicker and less mobile. The sebaceous glands are more active. The actual thickness of the epithelial structures is greater, as is the thickness of the subcutaneous tissue. This soft tissue of the tip varies considerably, the extreme being reached in the rhinophyma where the epithelial structures may sometimes be three-eighths of an inch in thickness (Fig. 28). Even under normal circumstances, or slightly abnormal circumstances of seborrheic inflammation, the tip of the nose may be quite fleshy, so that its shape is not due to the delicate lines of the cartilaginous structures but to the overlying covering envelope (Fig. 8).

CORRECTION OF THE LARGE OR HUMP NOSE

In planning the correction the balance of the patient's features must be considered. A prominent nose may appear even more prominent because of a receding chin (Fig. 25). In one instance a nose may be shortened more than in another where a long lower jaw is present. The proper width, height, and length of the nose must be determined in proportion to the other features. It is common for a patient to insist that all that is wanted is the removal of a hump. In most instances, when one feature of a nose is corrected, other faults are im-

Fig. 1. Plaster cast of the face used in planning nasal correction. One-half of the nose is carved down to represent the desired change. The other half of the nose is left intact for contrast. This method is quite objective and promotes accuracy of correction.

mediately accentuated. All of the component parts must usually be altered, and the preliminary planning is extremely important.

A number of rules or methods have been described for this. Some surgeons can do this free-hand, merely looking at the patient, studying the features, and making the decision without mechanical aid. It is felt that a more objective method is desirable. In every case a plaster cast is made of the face, and on this cast the correction is worked out, carving down the lateral half of the nose to represent the alteration planned, and leaving the other half for comparison (Fig. 1). By this method, the surgeon may fix in his own mind what he wants to do. The patient may also see what is being planned and more accurately describe his own ideas. Moreover, having this cast at the operation enables the surgeon to make excision of bone or cartilage by fairly accurate measurement. It is easy to get "lost" on the individual patient if the correction is being done free-hand.

Most nasoplasties involve certain standard corrections, the chief difference from one nose to the next being in the amount of excision at varying points. The more or less standard correction consists of lowering the profile line or removing a hump (Fig. 3). This results in a plateau on the top of the nose rather than a thin dorsum (Fig. 4). For this reason the nasal bones must then be narrowed, re-establishing the normally thin dimension. The tissue which is removed in correcting a hump or high profile line is the summit of the nasal bones, the portion of the upper lateral cartilages fused with the septum, which constitutes part of the width as well as the height of this hump, and a portion of the septum contribut-

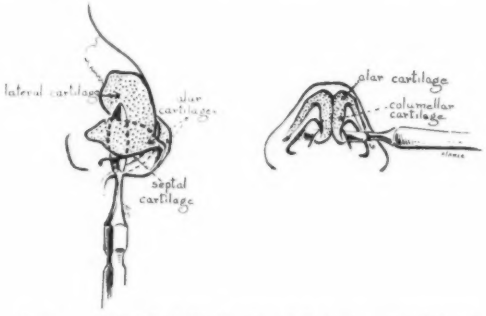


Fig. 2. a, left, The initial incision is between upper lateral and alar cartilages. The knife passes over the upper lateral cartilage and dorsum of the nose, separating all soft tissue from the cartilage and other structures constituting the hump. b, Having made the incisions in both nostrils, they are then extended medially to separate the columella from the lower border of the septum. These initial incisions do not cut cartilage, but separate one cartilaginous structure from another.

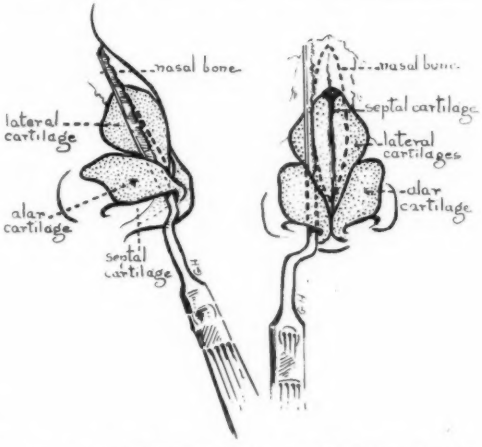


Fig. 3. After elevation of the soft tissues from the dor sum of the nose, the hump is removed with the Joseph saw The amount of excision is estimated from study of the cast which is present at operation. Note that the hump consist of bone, upper lateral cartilage, and nasal septum.

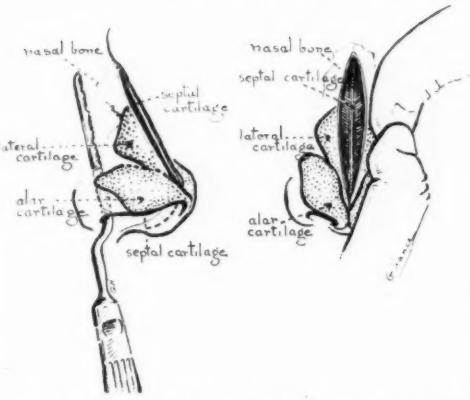


Fig. 4. a, left, An additional incision is made at lateral extremity of the initial cut between the upper lateral and alar cartilages. This goes to the inferior border of the frontal process of the maxilla. A Joseph periosteal elevator is inserted and worked up along the lateral wall of the nose, separating soft tissues from the nasal bone and frontal process of the maxilla, creating a tunnel to accommodate the Joseph saw. Both bony side walls of the nose are sawed through. b, After having removed the hump and made the lateral saw cuts, it is necessary to narrow the nose so as to recreate its normally thin dimension. Note that nasal bone, a medial portion of the upper lateral cartilages, and dorsum of the septum have been excised. If the saw cuts have been adequate, the nasal bones may be fractured in with relative ease; otherwise it may be necessary to complete the separation of the nasal bones, one from the other, with an osteotome.

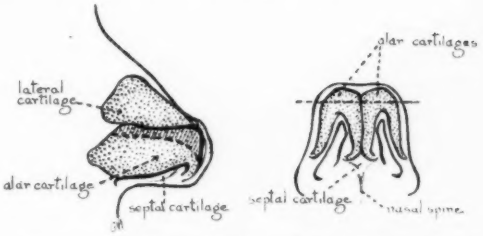


Fig. 5. a, left, The excision from alar cartilages varies in amount and location, depending on the desired correction. If the tip of the nose is too prominent, then the height of the cartilages must be excised, including a portion of the dome. If, however, it is not desired to reduce the height of the tip, but merely to make it more pointed, the excision does not include the medial portion of the cartilage supplying the height but involves that part of the dome which gives breadth. The portion which produces the lateral bulges on the tip of the nose is excised as shown in the shaded portion. The excision may be done submucously or the crus of the alar cartilage at the highest point of excision may be cut across, incising the mucosa and the cartilage. Following excision of cartilage, excess mucosa should be trimmed. Too great excision of cartilage and mucosa results in a pinched tip of the nose. At the termination of the excision, all parts should fit together accurately so that the entire nose is adequately lined. b, If the height of the tip of the nose is to be reduced, such an excision as shown would also permit the lateral portions of the alar cartilage to fall medialward, making the tip of the nose more pointed.

ing to the height of the profile line. The alar cartilages are corrected, either by removing some of the dome to lessen the height of the tip or some of the bulk of the wing of these cartilages to reduce the width and bulk of the tip or both (Fig. 5). The septum is shortened by removing a segment from its inferior border to reduce the length of the nose (Fig. 6). Having shortened the midline of the nose, it is

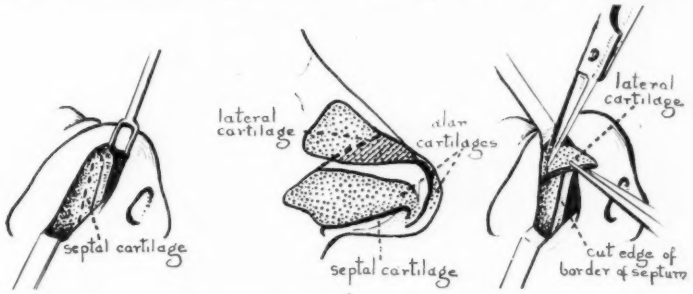


Fig. 6. a, The nose is shortened by excising a segment of mucosa and cartilage from the lower border of the septum. The shape of the excised segment and its size is determined by study of the cast. b, Excision of cartilage from the lower septal border will shorten the midline of the nose, but does not shorten the side walls. In order to accomplish symmetrical reduction it is necessary to shorten the upper lateral cartilages. The alar cartilage has already been reduced in size. The shaded portion of the upper lateral cartilage represents the amount of excision necessary to raise the side walls of the nose in proportion to the septum. c, Excision of triangle from inferior portion of upper lateral cartilage. This is done on both sides of the nose.

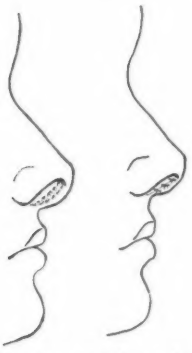


Fig. 7. Correction of a pendulous columella requires excision of some of the columellar cartilage. A full correction cannot be made by additional excision of septal cartilage. The excision represents removal of skin and inferior border of the hypertrophied cartilage.

also necessary to shorten the side walls so that the length will have been reduced symmetrically. This is done by excising a triangle from the inferior borders of the upper lateral cartilages. These corrections varying in amount and degree constitute the typical nasoplasty. To meet specific problems other maneuvers may be added.

Hanging columella. In some instances a hypertrophy of the columellar cartilages causes a down-bulging termed "hanging columella." It is a mistake to try to correct this displacement by excising more of the inferior border of the septum and forcing the columella up to it. A certain improvement may be gained in this manner, but the full correction will come from the excision of an ellipse of skin and columellar cartilage taken on either side of the columella just above its inferior border (Fig. 7). This ellipse is the length of the columella and varies in width, depending on the degree of the desired correction.

Secondary corrections. Although in most instances full correction is gained at the first operation, not infrequently small secondary corrections are desirable. There may be more relaxation of tissues and secondary drooping of the tip of the nose than are anticipated. This may produce a certain roundness of the profile just above the tip. Occasionally in dealing with large noses, the transverse distance between the base of the alae is too great. This may be narrowed at the primary operation. However, it is a small procedure and it

Fig. 8, above. Equally good results cannot be obtained in every case. The result of a nasal correction depends upon the absorption of excess skin and the soft tissues adapting themselves properly to the newly shaped skeleton. If the skin of the nose is normally thin, it may be expected to reflect the changes in the skeleton of the nose very accurately. However, if the soft tissue covering is thick and hypertrophied, the final result will lack the delicate lines and configuration desired. This complication must be foreseen. In some cases, it is perhaps wiser not to do the operation. In others, the complication must be explained to the patient beforehand so that too much will not be expected. a, left, In this case, tip of the nose is unusually high and the skin quite thick. Because of the magnitude of the desired reduction,

and because of the thickness of the skin, one would not expect a really good result following an operation. In some instances, further help may be gained by excision of a prism or section of the full thickness of the ala at its junction with the cheek. This was done in this case, and the result shown in b, right, is a decided improvement.

Fig. 9, above. a, left, Facial deformity of relatively common type. Note retrusion of middle portion of face. The tip of the nose is less prominent than the dorsum and is situated in a depressed area. The attachment of the ala to the cheek and the base of the columella are retruded. The columella forms an acute angle with the lip, and the lip forms too great an angle with the vertical profile line. b, Correction in one operation by technique in Figure 10.

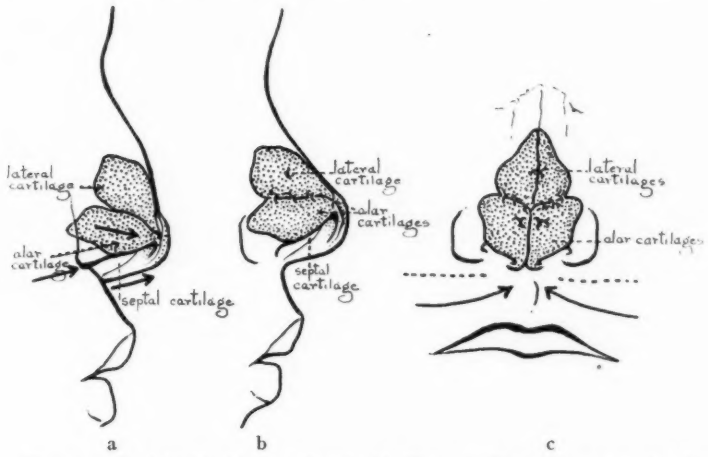


Fig. 10. a, The initial incisions are described in Figure 2. The incision separating the columella from the lower border of the septum is continued deep enough to enter the upper labial sulcus. A transverse incision is made in the upper labial sulcus from the molar region on one side to a similar point on the opposite. The upper lateral cartilages are divided from the septum on either side. The upper lateral cartilages are then sutured together over the septum to fill in the slight depression above the tip. The alar cartilages are sutured forward in an advanced position on the lower border of the upper lateral cartilages as illustrated in b. The columella is sutured in a forward position on the lower septal border. The tissues of the lip and cheek are advanced toward the midline as shown in c, and sutured in such position as to build up a greater bulk of soft tissue under the base of the alae and columella, forming a tip of the nose which is now more prominent than the dorsum, and correcting a retruded position of the base of the alae and lip.

is felt that it can be most accurately done after the nose has recovered from the operation, and the proper final relationship of the base of the nostrils to the point of the tip can be ascertained. If too much narrowing of the base of the nostrils is done, then the nose viewed from below is not triangular but more globular than normal.

The nose with a very fleshy tip does not lend itself well to correction. Here the shape is due more to the thickness of the skin than to the contour of the alar cartilage. In lesser degrees, this may be corrected by trimming subcutaneous tissue from between the alar cartilages and skin and removing the attached areolar tissue from the external surface of the upper lateral cartilages.

External excisions. In certain larger and grotesque noses, it is necessary to make excisions of prisms of skin and subcutaneous tissue from the base of the alae at their attachments to the cheek (Fig. 8). This is not often

Fig. 11. Typical unilateral, complete cleft of lip and palate with the correction of the lip and nose that may be obtained at primary operation. This involves an incision between the upper and lower lateral cartilages with undermining of the alar cartilage, separating it from the skin of the nose. This wide undermining is usually done from the single incision between the upper and lower lateral cartilages. This permits shifting of the lining and covering of the ala in the process of re-establishing the floor of the nostril and curling the ala into its proper position. Often the correction cannot be made as good as it is ultimately desired. Moreover, some increasing deformity may occur with growth.

a b c

Fig. 12. a, Deformity of nose secondary to cleft lip. Here inadequate primary repair was done and the deformity subsequent to the initial repair has increased. The nose is not in the midline and there is a decided slumping of the left alar border. b, Shows correction obtained by shifting the nose to the midline, reoperating upon the lip, advancing the entire left ala, and repositioning alar cartilages as shown in Figure 27. c, Shows relative symmetry of the tip and a scar above the left nasal border, representing removal of a crescent of skin. Such an excision should never be made at the primary repair of the cleft lip.

necessary. In general, where it is necessary, the overall correction of the deformity will not give a result comparable to that obtained on less extreme cases.

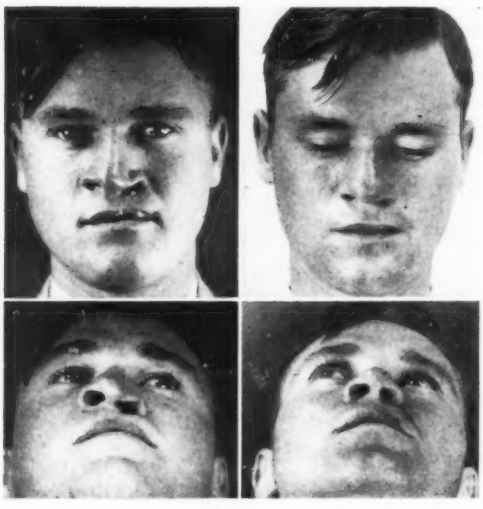


Fig. 13. Case similar to that illustrated in Figure 12, showing the rather extreme alar deformity which may occur subsequent to inadequate primary repair and which may also become more noticeable with growth and development of the nose. Repair was done by the scheme outlined in Figures 12 and 27.

Septal resection. The operator is often at a disadvantage if a septal resection has been performed prior to the nasoplasty. The removal of a hump could result in the disturbance of the remaining septal support of the dorsum. The adequate shortening of a drooping tip could necessitate the removal of the remaining inferior septal border with loss of tip support. If the septal resection is performed prior to the nasoplasty with the knowledge that the second operation is contemplated, these factors should be considered.

SNUBBED TIP AND RETRUSION OF THE MIDDLE THIRD OF THE FACE

Normally the tip of the nose is its most prominent portion. In certain cases the tip of the nose may be less prominent than the dorsum (Fig. 9). This does not refer to the loss of tip support following trauma or operation but to a congenital condition. In such cases the columella is short. The alae are set in a depression; the base of the upper lip is retruded; the upper lip rather than being more or less vertical protrudes so that its border is anterior to its base at the junction of the lip with the nose and columella. The correction of such a deformity entails the advancement of the entire tip of the nose and the upper lip so that the soft tissues on which the tip of the

Fig. 14. Illustrating the improvement in general facial appearance which may sometimes be gained by doing a complete nasoplasty at the time of correction of residual cleft lip deformity. The correction of the deformed tip of the nose involved reduction in size of the alar cartilages so that they were symmetrical in size and position.

nose rests have also been brought forward (Fig. 10). The entire procedure must be made rather extreme because in the first few weeks following operation there will be a tendency for the tissues to settle and a portion of the correction will be lost.

NASAL ASYMMETRY ASSOCIATED WITH HARELIP

In the complete unilateral cleft lip, the cleft extends through the floor of the nostril (Fig. 11). The ala and alar cartilage on the affected side are pulled out into a straightened and distorted position. This can largely be corrected at the primary operation if it is done properly. However, residual asymmetries are often present (Figs. 12, 13, 14, and 15). In the partial unilateral cleft lip, the cleft does not go through the floor of the nostril, but there is

Fig. 15. The patient with deformity resulting from one single factor, such as cleft lip, may often be given a better overall result by correcting not only the primary fault, but other bad features as well. a, left, Illustrates deformity of upper lip and nose resulting from a cleft lip. Note also the prognathism. b, Illustrates the improvement which was gained by reoperating upon the lip and correcting the nose according to the technique illustrated in Figure 10. The prognathism was corrected by excising the lower border of the point of the mandible. The scar of the submental incision may be seen. The excised segment of bone is shown below.

attendant nasal deformity on this side. Provided good correction has been made at the original operation, then the deformity present usually consists of a few definite distortions. The attachment of the ala to the cheek on the cleft side is often posterior to the normal (Fig. 13). The alar cartilage on the cleft side is underdeveloped and smaller than its fellow, causing a slumping of the alar border. The entire alar cartilage on the affected side has a more posterior position than its fellow. This is true also in its relationship to the upper lateral cartilage. The entire nose, including the bony nose, may be deviated from the midline (Fig. 21).

Often the operation may entail a complete nasoplasty and general reduction of size (Fig. 14). If this is done, then by reducing the size of the normal alar cartilage, the two may be more likely to compare favorably. Otherwise the adjustment must come in repositioning the alar cartilage on the affected side. One method of doing this is as follows. An incision is made between the alar and upper

Fig. 16. a, left, Large and unsightly nose, associated with breathing difficulties. The lower border of septum blocks the left nostril. The right nostril is blocked by the angle of deflection. In this case correction was obtained by doing a typical nasoplasty, reducing the nose in size and shortening it markedly. The amount of shortening permitted excision of a large triangle from the lower septal border, allowing the excision of the entire obstructing portion. It is unusual to be able to shorten a nose to this degree. However, in many cases, a part of the correction may be so gained. b, Shows the improvement in appearance and in airway. The "hanging columella" operation (Fig. 7) was also carried out on this patient. No septal resection was done.

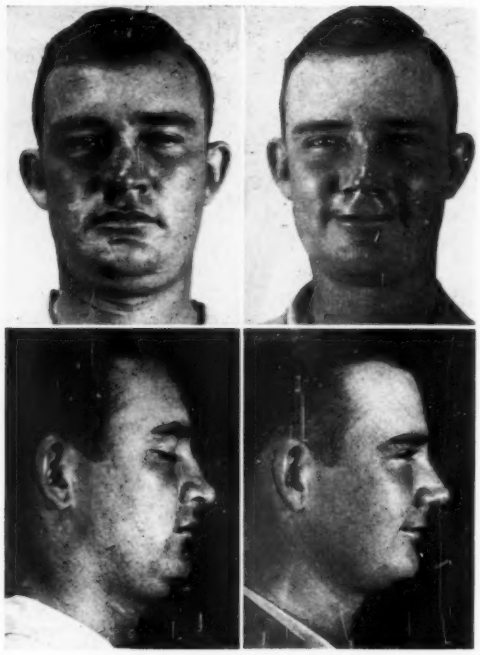


Fig. 17. a, left, Typical crooked nose resulting from childhood injury. A septal resection had previously been performed and patient's airway was adequate. b, Shows improvement which was gained by shifting the nasal bones to the midline and shortening the nose considerably. This permitted elimination of the supra-tip depression. The lower lateral cartilages were advanced on the remnants of the upper lateral cartilages remaining after shortening the nose. The shortening of the upper lateral cartilages rendered them more stiff and stubby, permitting better support to the nasal tip. The drooping due to partial loss of tip support in this case was corrected by substituting the support of the upper lateral cartilages for that normally supplied by the septum.

lateral cartilages on the affected side, with free undermining of soft tissues. The alar cartilage is then sutured forward to climb the upper lateral cartilage to a more advanced position. The alar cartilage is then mobilized as in the usual nasoplasty, with the exception that its lateral portion is not divided from the columellar portion and is mobilized submucously. The columellar portion of this cartilage is sutured to overlie the dome of the normal cartilage (Fig. 27). This deprives the columella on the affected side of this columellar cartilage and adds the columellar portion to the alar cartilage which in itself is congenitally underdeveloped and small. A considerable improvement of the tip deformity may thus be obtained. If there is still some slumping of this alar border, the excision of an ellipse of skin from above the alar border at the tip of the nose may raise this (Fig. 13).

The proper correction of the tip of the nose associated with the cleft lip often entails the reoperation of the lip, correcting such displacements as are present in the lip itself.

The double cleft lip is considerably more of a problem than is the single cleft, both from the standpoint of primary repair and secondary correction of the nose. With the double cleft, especially of the complete variety, there is almost complete absence of the columella, the tip of the nose being adherent to the lip. This cannot be corrected at the primary operation. Associated with this absence or partial absence is a congenital deficiency of

Fig. 18. a, left, Twisted nose resulting from childhood injury, plus secondary loss of tip support and increasing drooping of the nasal tip following septal resection. b, Shows correction obtained by shifting the bony nose to the midline, shortening the nose markedly, and gaining support by utilizing the remaining portion of upper lateral cartilages, as in Figure 17.

the alar cartilages and the columellar cartilages. Secondary to this deficiency and distortion of the tissues, there is a developmental distortion, resulting in malposition of such cartilage as is present. The complete correction frequently calls for multiple operations and a combination of procedures. First, it is often necessary to advance the tip of the nose, carrying with the columella an attached strip of tissue from the center of the upper lip, thus lengthening the columella. Later, a batwing, or modified "V" type of incision can be made across the tip of the nose, turning up the skin and underlying soft tissue and exposing the alar cartilages at the dome. These cartilages can then be sutured together in the midline to give a more pointed tip and the skin incision closed as a "Y," advancing the soft tissues to give a more prominent tip. Subsequent to this, the procedure as described under "Snubbed Tip and Retrusion of the

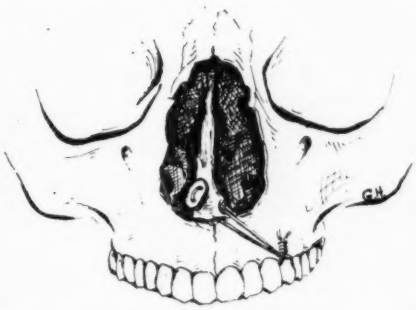


Fig. 19. It is sometimes difficult to maintain a midline position of the lower septal border. If there is a resistance to the shifting of its position, a more rigid method of holding it may be desirable. In such cases a silver wire may be passed around the mobilized spine over a small lead button. This wire can be attached to a tooth on the opposite side, anchoring the displaced septum in a position of overcorrection until healing occurs.

Middle Third of the Face" may be carried out. With many cleft lips, associated with cleft palates, there is some underdevelopment of the maxilla. This underdevelopment of the maxilla may be associated with a relative or combined relative and actual overgrowth of the mandible, giving an appearance of prognathism (Fig. 15). In order to get the best balance of the features and to shorten the lower third of the face to make it in proportion to the middle third, an excision of bone from the mandible or the point of the chin may be done.

DEVIATIONS OF THE EXTERNAL NOSE FROM THE MIDLINE AS THE RESULT OF TRAUMA, AND ASSOCIATED SEPTAL DEFORMITY

Everyone in infancy or later has had trauma to the nose. Even relatively slight trauma in early childhood, with no deformity at that time, may result in increasing external deformity of the nose with growth. The typical history of such a case is that of a mild injury at 5 or 6 years of age, with slight deformity beginning at about 12 years of age and reaching a maximum at 16 or 17. In these cases, the anterior view of the nose shows it to be somewhat of an S-shape, the bony portion being deviated to one side, the middle third curving to the opposite side, and the tip usually deviating in the same direction as does the bony nose (Figs. 17 and 18). It is presumed that in

Fig. 20 a, left, Illustrating the extreme depression of bridge resulting from an abscess and loss of septum in childhood. Not only is there loss of septal support but a portion of the growth stimulus to the nose has been lost. This results in an overly short nose out of proportion to the length of the rest of the face. The soft tissue covering and lining of the nose is deficient. If allowed to persist through the growing period, correction becomes increasingly difficult because of the relative deficiency of soft tissues. b, Shows correction gained at the age of 15 years by the insertion of a section of maternal cartilage. Such a correction done at an earlier age will aid in growth and development of the soft tissues of the nose, permitting the removal of the original implant and insertion of a larger one in later years.

such instances injury occurring to the septum with displacement of its attachments and perhaps hemorrhage within tissues has resulted in an increasing deformity with growth,

Fig. 22. a, left, Depression of entire dorsum of nose secondary to infection in childhood. In this case the infection occurred late in childhood, and there is less shortening of the nose than in Figure 19. However, there is a deficiency of bone as a result of the lack of growth stimulus. In many such cases there is a widening of the nasal bones, necessitating their being narrowed prior to building up of the profile line. Correction here was done in two operations with the result shown in b. At first operation the nasal bones were narrowed; at the second, a right angle support of rib cartilage was inserted to build up the dorsum and correct the retruded position of the columella.

Fig. 21. a, left, Depression above tip resulting from abscess of the septum in adult life. Here, septal support is lost. There is no change in the shape of the nasal bones since full growth had occurred prior to the infection. There is a shrinking of the soft tissues of the lower portion of the nose, secondary to the loss of supporting structures. b, Correction gained by insertion of triangular piece of rib cartilage. Such a nose can rarely be built to its original size because of the shrinking which has occurred in the soft tissues.

the external nose being carried into the deviated position by the increasing distortion of the septum. In addition, any trauma in later life can cause deviation of the bony nose and of the septum. As before stated, almost all corrections of the external nose are made with the technique of the typical nasoplasty as the underlying principle. This is varied to meet individual cases. Correction entails bringing the bony nose to the midline, providing adequate breathing space and straightening septal structures which are causing deviation of the lower or cartilaginous portion of the nose. This may be combined with removal of a hump or other corrections of displeasing lines of the external nose. The bony nose is brought to the midline by free mobilization of the nasal bones and shifting them according to the technique described under "Nasoplasty." A removal of a certain amount of septum is usually necessary, first to provide breathing space by the removal of obstructions and second to weaken the septum, diminishing its resistance to straightening. The lower border of the septum often offers the greatest problem. Frequently there has been a dislocation of the septum from the vomer and the lower border may be turned almost at a right angle, one nostril being obstructed by the bend or

Fig. 23. Supratip depression as a result of trauma. Correction consisted of septal resection to restore breathing space, removal of a slight amount of the prominence of the nasal bones, shortening the nose, and building up the depression above the tip by suturing together of the upper lateral cartilages across the dorsum of the septum. No implant was done.

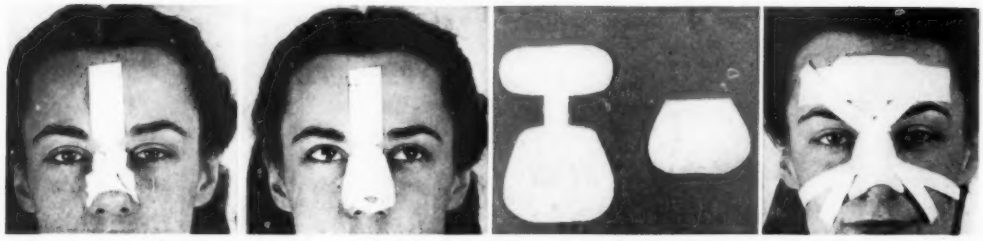
angle of deflection, the other by the free lower margin projecting into the opposite nostril. The best correction of this condition can be obtained by shortening the nose and excising the portion of the septum which is deflected (Fig. 16). Naturally this cannot be done in many cases because often a nose cannot be shortened to this degree and preserve a good appearance. In most instances it will be necessary to straighten this lower portion of the septum so that it again is in the midline. This relieves obstruction, corrects the deviation of the tip of the nose and restores support of the septum to the tip of the nose. This involves freeing of the lower portion of the septum from the angle of deflection to the lower border so that it may be moved like the rudder of a boat. The submucous resection having been done if necessary, superior to the angle of deflection, a chisel is driven along the floor of the nose, cutting free the base of the septum and vomer from the palate. If done adequately, this will permit bringing the lower section of septum to the midline. If there is resistance to the shifting of the position or if it does not remain freely in the new position, it may be held by wiring to a tooth on the opposite side (Fig. 19). The inferior border of the septum is set into the groove between the columellar cartilages. Following complete healing, a limited secondary resection of this inferior portion of the septum may be necessary.

Fig. 24. Loss of septum from infection. This case was identical in history with that illustrated in Figure 21. However, correction was made by utilizing local tissues entirely as in Figure 23. Having had a high nose originally, it was possible to remove some of the nasal hump, making the depression relatively less deep. The nose was shortened and the upper lateral cartilages sutured together to fill the supratip defect. In this case, it was possible to shorten the nose somewhat, facilitating this technique. In the patient shown in Figure 21 the nose was already too short and it was desirable to add to its length, making it unsuitable for utilization of local tissues only.

DEPRESSED NOSE

As the result of trauma, infection, or operation, the profile line of the nose may be depressed in part or throughout. If such an injury occurs in childhood, the resulting defect is twofold. First there is flattening as the result of the injury, and second, a failure of de-

Fig. 25. a, left, Illustrating necessity of considering all of the features when planning a correction. The prominence of the nose in this case is accentuated by the receding chin. b, Shows correction of receding chin by implantation of rib cartilage to supplement the point of the mandible, and subsequent nasoplasty to reduce the size of the nose and improve its shape.



a b c

Fig. 26. The postoperative care and dressing is almost as important as the operation itself in getting a good final result. In applying this, one should remember that the dressing should attempt to do everything that was accomplished in the operation. The shortening of the nose should be maintained by holding the skin of the nose upward with adhesive strapping. The reduction of the hump should be supported by transverse strapping of the upper portion of the nose with adhesive tape. The narrowing achieved at operation must be held by splinting the nose in a narrowed position. If there has been a deviation of the nose from the midline, the dressing should attempt to correct this deviation. a, Shows the adhesive strapping of the nose and the application of two small felt or adhesive pads stuck on with collodion. By application of a splint over these pads, correction or even overcorrection of existing deviations may be obtained. Such pads and counterpads are usually not applied at the original dressing, but are used at subsequent dressings as indicated. b, Shows small nasal splint of adhesive covered aluminum applied over adhesive strapping. This splint may be bent easily with the fingers and shaped by trimming with bandage scissors. It adheres to the nose through the medium of flexible collodion. c, Shows a different pattern of splint made of same material. In this case the splint is not attached to the nose with collodion, but is held in place with adhesive strapping. This adhesive strapping permits holding the splint and soft tissues of the nose backward more tightly against the skeleton. This is most commonly used as the primary dressing, changing to the smaller splint for subsequent dressings. A 12 day period of splinting is adequate for the simple, uncomplicated nasoplasty. Where corrections of deviations of the nose from the midline have been done the period of splinting may be for longer periods.

velopment of the external nose in proportion to the other features (Fig. 20), and the nose is often widened.

The correction of such a condition involves the transplantation of some solid substance to supplement the normal supporting structures and restore the proper profile line. The transplanted material may be one of several. An autotransplant of cartilage taken from the patient's ribs is perhaps the best. This material is rigid and yet may still be carved with the scalpel. It is a living transplant of the patient's own tissue that heals well in place and is not subject to absorption or extrusion. The disadvantages are that an incision into the chest is required to procure the cartilage and after transplantation it sometimes has a tendency to curl, so that the straight line obtained at operation is not maintained. Preserved cartilage at the present time is being used quite extensively, often with quite good results. Its disadvantages are that it is a foreign body, and although it usually heals in place with very little reaction it is sometimes

Fig. 27. a, left, Inferior view of deformity of alar cartilages frequently found associated with unilateral cleft lip. b, scheme utilizing columellar portion of underdeveloped alar cartilage on the cleft side to restore symmetry of nasal tip.

Fig. 28. a, left, Rhinophyma of many years' duration with associated basal cell carcinoma in a limited area. b, Result from shaving down thickened skin to the basal layers and shortening nose as in typical nasoplasty. Area of malignancy excised with the cautery and allowed to heal spontaneously.

absorbed and does not tolerate infection at all well. It does not have the tendency to curl. Living bone is difficult to shape and to obtain does require operation on the patient. Ivory and synthetic materials have the advantage of being easy to obtain but are rather difficult to shape at the operating table. These also are foreign bodies and are not as well tolerated by the tissues as are some other materials. It must be remembered that any transplant to the nose may be somewhat movable so that the patient may shift it slightly from side to side over the underlying structures unless it rests solidly on periosteum of the underlying bones. If so placed it adheres tightly to the periosteum and is not movable. Any transplant should supplement the deficient structures. Usually the transplant will overlie the depressed nasal bones. Inferior to this point it will supplement the septum and upper lateral cartilages which are also depressed. A single dorsal implant may be all that is needed if this implant adheres solidly to the nasal bones and gives adequate tip support, acting as a cantilever. However, oftentimes the backward pull of the tip is such that adequate support cannot be gotten from a single dorsal implant. Also it is often necessary or desirable to lengthen the nose, bringing the columella down into a lower position. In this case, the most desirable implant is a right angle in shape (Figs. 20 and 22). This is not the hinged transplant described by Gillies, which we have found impractical, but represents a right-angled insert carved from a single piece of cartilage taken from the curve of the rib cartilage near where it articulates with the rib. This is inserted through a columella-splitting incision, the longer dorsal projection resting over the nasal bones and elevating the profile of the nose. The shorter right-angled portion lies in the columella, forcing it downward into a more desirable position and elevating the nasal tip. This supplements the quadrilateral cartilage and supplies the support which it normally would provide. In certain instances, rather than using a right-angled insert, two separate implants can be used, one in the dorsum and the other in the columella, and these are attached with a silk suture at their junction. These implants are shaped at the operating table with the scalpel, the same scheme being followed if preserved cartilage is used.

Often rather severe trauma to a nose will not fracture the nasal bones at all but will depress the septum, causing a depression inferior to the border of the nasal bones and above the tip (Fig. 23). Such a depression may be handled in one of several ways. Most satisfactorily, some of the height of the nasal bones may be removed, making the supra tip depression relatively less deep; the upper lateral cartilages can then be detached from their connection with the septum and sutured together over the dorsum of the septum to elevate a portion of the depression (Figs. 23 and 24). If the nose can be shortened, this will then bring the tip or alar cartilages into a higher position, encroaching on the neighborhood formerly occupied by the depression and helping to obscure it still further. Some operators prefer the transplantation of one or more thicknesses of ear cartilage for these small defects. Usually if the depression is so slight that it may be satisfactorily filled in with a thin implant of this type, it can be better corrected by superimposing normal nasal structures. Moreover, it is often difficult to place small bits of cartilage accurately in such a defect, and after healing the result will not be entirely symmetrical, the implant not fitting accurately to the depression. If the defect cannot be hidden by superimposing normal nasal structures over it, then it is usually safer to use a larger implant of rib cartilage.

A deformity occasionally following septal resection is the loss of support, causing a drooping tip. This gives an effect of elongation of the nose, the tip being less high from the lip than the position it formerly occupied (Fig. 18). Correction may be made in one of two ways. Through a columella-splitting incision, a post of cartilage may be transplanted nto the columella itself, simulating the support originally given by the lower border of the septum. In other instances where appearance will permit, it is possible to shorten the nose, especially the side walls, rendering the upper lateral cartilages less long and therefore more stubby and stiff. This supporting stiffness of the upper lateral carti-

lages may then be transmitted to the tip of the nose by suturing the upper border of the lower lateral cartilages to the upper laterals, substituting the support of the upper lateral cartilages for the lost support of the septum (Figs. 17 and 18).

CARCINOMA OF THE VULVA

Results of Treatment and Effect of Special Factors on Results

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CARCINOMA of the vulva represents only about 4 per cent[1] of all cancers of the female genital tract (4,5,8,13). Yet on account of the opportunity it offers for early diagnosis, and the obvious failure to take advantage of this opportunity, evident in most cases, it deserves increased emphasis out of proportion to its incidence. This is especially so in view of the fact that increased knowledge in the treatment and prevention (19) of this type of cancer has been established during the past 5 years; knowledge which may reduce somewhat the high mortality rate of the condition. The bulk of these cancers, and this includes the vestibular and periurethral lesions, are skin cancers, but because of their presence and location in a relatively specialized organ which is bathed in rich lymphatic trunks, it becomes not alone a local problem but, like breast cancer, one in which equal consideration must be given to the possibility and location of metastases.

Over a period of many years, a more or less standardized method of treatment has been developed for most cases of vulvar carcinoma. It is our purpose to evaluate the method in use at the Memorial Hospital with a brief description of some of the clinical and pathologic features of this disease. That this form of cancer is relatively uncommon (19) is not questioned, yet despite this fact the literature is replete with statistics of end-results and methods of treatment (5,13,15,16,18), histologic forms (2,10,12,21), age incidence (6,14), prevention (19), and general clinical description (8). However, since Welch and Nathanson's review of their material reporting on life expectancy and incidence of carcinoma of the genitourinary tract, material to 1933 only, there have been no recent survival figures on a fairly large series. We shall present survival times of all primary cases seen at Memorial Hospital through 1940 as well as survival figures for those patients in the various stages of the disease process. Certain prognostic differences according to location and histology as well as extent of disease were also investigated.

During the 20 year period between 1926 through 1945, there have been 244 cases of cancer of the vulva at Memorial Hospital. For the purpose of this report, we have divided this number into 2 groups: the primary cases, 167, or those patients who came here without any form of previous treatment; and the secondary cases, 77, those who had received treatment in the form of either x-ray, radium, or surgery at another institution. The primary group forms the basis of this report; a brief discussion of the secondary cases will be given at the end. Because 16 patients did not have a histologic diagnosis of cancer, this number was dropped from our study, leaving an overall total of 228 histologically proved cases.[2]

ETIOLOGIC FACTORS

In our series, the youngest patient with a malignant epithelial tumor of the vulva was 27, the oldest 89. Nine patients, or 4.1 per cent, with carcinoma were below the age of 40. Although this is a relatively small percentage,

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[1] There were 4,844 patients seen at Memorial Hospital between 1926 and 1943 who had cancer of a gynecologic organ; 225 of these had cancer of the vulva, or an incidence of 4.6 per cent.

[2] Of the 16 patients, 2 (12.5 per cent) are free from cancer well over 5 years; the remainder all died before the fifth year. At death the clinical diagnosis was carcinoma, vulva primary.

it serves to remind one that vulvar carcinoma occurs in younger women not infrequently. Shannon and Marting reported a case complicating pregnancy in a 26 year old woman and also reviewed from the literature 5 cases of carcinoma of the external genitalia associated with pregnancy. Its presence in children, where it becomes an oddity, has been reported on by Hoge and Benn. Baldwin's youngest patient was a girl of 14 who had a primary carcinoma of the vagina. In the present series, one of the patients with a melanoma was 15. Thirty-eight and seven-tenths per cent of the patients were between the ages of 60 and 69; 25.4 per cent between 50 and 59; 18.3 per cent were between 70 and 79; and 8.7 per cent were 40 to 49. Forty-nine and five-tenths per cent of the patients were married, 36.6 per cent were widowed, and 13.6 per cent were single. Seventy-five and six-tenths per cent had one or more children, 24.4. per cent were nulliparous. The high percentage of widowed patients is undoubtedly due to the large number in the older age groups and seems of no related significance.

Eight patients had syphilis, but we were not struck by any difference in their disease as compared with the nonluetics. There were 10 diabetics recorded, and 1 patient had a positive Frei test. None of these illnesses seemed to play a part in the etiology of the condition unless the vulvar pruritus commonly present in the diabetic can be termed a predisposing factor.

SYMPTOMATOLOGY AND SIGNS

In 70.1 per cent of the patients, the presence of the lesion itself was the chief reason for seeking medical care. Pruritus, pain, and bleeding, in that order, were the most common symptoms. Only 30 patients complained of increased vaginal discharge, but a relatively high number, 47, noticed urinary burning and frequency. Two patients had dyspareunia.

From our series, the importance of pruritus as a cancerous and precancerous symptom is undeniable. Itching and burning about the vulva was present in 128, or 56.1 per cent, of the patients. Associated with this number were 83 patients (36.4 per cent) who had leucoplakia. As pruritus is the cardinal symptom of leucoplakia this is not surprising. Nevertheless, the presence of these two factors despite the absence of other signs warrants vigorous treatment in the form of excision rather than close observation and temporization. The relationship between leucoplakia, as a precancerous lesion, and true cancer of the vulva is too well known for conservative therapy to be the method of choice.

HISTOLOGY

The histologic forms present in our series were as follows: epidermoid carcinoma, 189; melanoma, 25; basal cell carcinoma, 9; adenocarcinoma—Bartholin gland, 2; vulvar Paget's carcinoma, 1; dermatofibrosarcoma protuberans, 1. Blair-Bell and Datnow state that malignant disease of the vulva occurs as squamous carcinoma in over 90 per cent of all cases. This statement is found to be closely approximated by our series in which 84.0 per cent of the patients had an epidermoid type of carcinoma. Almost two-thirds of these (63.3 per cent) were grade II lesions.

A surprisingly high number, 25 or 11.1 per cent, of melanomas are present in our series. Taussig (17) found 3 in his series of 155 patients. Folsome reported that he had found only 3 cases of melanoma of the vulva in the files of the University Hospital in Ann Arbor, between 1901 and 1940, or an incidence of 1 case to each 125,000 pelvic examinations. Although this type of lesion in general is rare, it has been seen not infrequently at our institution, probably because we recommend excision of most pigmented tumors on and about the vulva.

Nine, or 4.0 per cent, of the lesions were basal cell carcinomas. Berman reported on 4 patients with this type of cancer seen in St. Louis between 1927 and 1941. Wilson describes 4 cases collected by him from a series of 32 patients with carcinoma of the vulva seen at the Duke Hospital, an incidence of 12.5 per cent. Goebel and Hamann reported an incidence of 14.7 per cent basal cell carcinomas in their group, but they note that this percentage is higher than any other obtained in the 5 years previous to their report. Folsome notes that basal cell cancers of the vulva are relatively rare, there being 6 cases in his report.

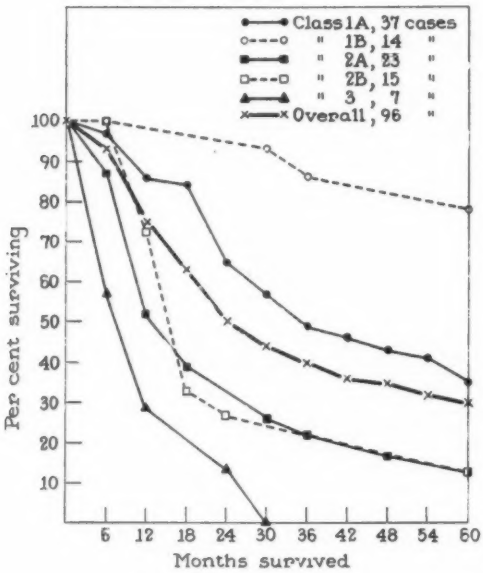

Chart 1. Survival curves.

TABLE I.—CARCINOMA OF THE VULVA—5 YEAR CURE RATES

Total number of cases	Primary 100	Secondary 46	Total 146
Indeterminate cases			
Dead of other causes—no evidence of cancer	7	1	8
Lost track of—no evidence of cancer	3	3	6
Total number of indeterminate cases	10	4	14
Determinate cases			
Total number studied minus indeterminate cases	90	42	132
Failures			
Dead of cancer	62	30	92
Lost track of—cancer present (probably dead)	2	0	2
Living—cancer present	0	0	0
Total number of failures	64	30	94
Successes			
Without evidence of cancer 5 years after application for treatment	26	12	38
Net 5 year cure-rate			
Successes divided by determinate cases	28.88%	28.57%	28.76%
Absolute 5 year cure rate			
Successes divided by total number of cases	26.00%	26.08%	26.02%

There were 2 patients in our series with adenocarcinoma of Bartholin gland origin.

Sarcoma of the vulva is rare. It may occur initially in the tissues of the vulva, or in the vulvar end of the round ligament, or it may represent sarcomatous change of a previously situated vulvar tumor. Taussig (15) notes that Leonard found 22.5 per cent of fibromas and fibroleiomyomas of the vulva that showed sarcomatous change. However, Lovelady and associates, in a report on 34 benign neoplasms of the vulva, noted no sarcomatous change in any of their tumors. Folsome reported 1 out of 9 such tumors showing change.

END-RESULTS AND EFFECT OF SPECIAL FACTORS ON RESULTS

The end-results of the primary and secondary groups of histologically proved cases seen between 1926 through 1940 is given in Table I. We have used the customary form in use at Memorial Hospital for reporting end-results. It deals solely with the overall cure rates and includes all of the histological types mentioned above. Our absolute 5 year cure rate is 26.00 per cent.

Clinical classification. This figure, being a summation of all our cases, represents only a small part of the problem. We were especially interested in proving the importance of various factors on end-results. To determine the effect of extent of disease, the cases were divided into five classes: (1) Cases without involvement of inguinal nodes—(A) with no extension of disease beyond the primary site on clinical examination, and (B) those in which the inguinal nodes were dissected or biopsy tissue examined and no cancer found on pathologic examination. (2) Cases with inguinal nodes involved but operable—(A) those in which inguinal nodes were probably involved or enlarged on clinical examination and (B) those in which inguinal nodes were dissected or biopsy tissue examined and found positive for cancer on pathologic examination. (3) Inoperable cases; with inguinal nodes fixed or immobile; swollen leg.

The survival curves of the primary group of patients in these classifications are given in Chart 1. All patients were treated by one or a combination of accepted methods; x-ray, radium, or surgery. The total number of pa-

tients charted was 96. As would be expected, those patients in class 1B, those whose inguinal nodes were negative on pathologic examination, showed the highest survival figures. The rapid fall in the curves of classes 2A and 2B emphasizes the markedly changed prognosis once the disease has extended beyond its primary site.

Results in relation to type of surgical treatment. Twenty-one patients had a vulvectomy alone (Table II)[1] with one postoperative death. Five of these patients had enlarged inguinal nodes at operation and only 2 of this number survived 5 years. The overall 5 year cure rate for the 21 patients was 47.6 per cent. A higher survival rate would naturally be expected in this group as the disease was presumably limited to its original site when operation was undertaken. The fact that over 50 per cent of these patients did not survive 5 years emphasizes the high incidence of metastases which are not clinically discernible and should influence the procedure followed in treating these lesions.

Of 7 patients who had wide local excisions of the vulvar lesions, mainly because of general debility and old age, only 3, or 42.8 per cent, survived 5 years.

There were 19 patients who had a vulvectomy with bilateral groin dissections. In all cases, the groin dissections were done at intervals of about 10 days, following the vulvectomy, and included dissection of the superficial and deep inguinal nodes, including the so called Cloquet or femoral canal node, but did not include the removal of the nodes along the hypogastric and iliac chains. Ten patients in this group (Table II) had negative inguinal nodes on pathologic examination and 8, or 80 per cent, of these survived 5 years. Nine patients (Table II) had positive inguinal nodes and only 2 or 22.2 per cent survived 5 years. In 1 of these 2 survivals, however, the primary lesion on the vulva was a melanoma.

Four other patients had a vulvectomy followed by bilateral groin dissections of the Basset type, done at intervals of about 10 days. Three of these were patients whose inguinal and iliac nodes were positive for carcinoma and they died within 2 years. The remaining patient is without evidence of disease today, well over 5 years, but her nodes showed no evidence of cancer on histologic examination.

TABLE II.—RELATION OF SURGICAL TREATMENT TO END-RESULTS

	Vulvectomy		Vulvectomy and bilateral groin dissection			
Class	1A and 2A(5)		1B		2B	
	No.	Per cent	No.	Per cent	No.	Per cent
Number of cases	21		10		9	
Alive at 2 years	12	57.1	9	90	3	33
Alive at 5 years	10	47.6	8	80	2	22.2

Six patients had a vulvectomy and a unilateral groin dissection of the more superficial type. Four of these whose nodes were positive died within 2 years. One, whose nodes were negative, died within 30 months. The sixth patient had a melanoma which did not metastasize to the inguinal nodes until 7 years after a vulvectomy was performed. She died 6 months following a unilateral groin dissection.

Since 1940, almost all of the groin dissections done at Memorial Hospital have been of the Basset type, but it is still too early for definite end-results to be drawn. No postoperative deaths were encountered following any of the groin dissections.

Effect of radiation therapy. The inadequacy of x-ray and radium in treating either the primary or metastatic foci of this condition is well known (4,7,17,18). Only 4 patients were given x-ray therapy to the vulva alone. All died within 18 months but 2 of these were beyond cure at the onset of treatment. One had a node removed from the supraclavicular area which on pathologic examination was consistent with a vulva primary.

There were 8 patients who received radiation to the vulva and groins, and of these only 2 (25 per cent) have been well over 5 years. In each of these, the primary lesion was believed to be limited to the vulva only.

Eighteen patients were treated by vulvectomy and then were given radiation in the form of x-ray, radium element pack, or radon

[1]As a majority of patients succumb within 2 years, this figure is also given.

TABLE III.—RELATION OF ANATOMIC LOCATION TO END-RESULTS

Location	Labia majora		Labia minora		Clitoris		Posterior commissure	
	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent
Number of cases	54		23		12		8	
Alive at 2 years	28	51.8	12	52	5	41.6	7	87.5
Alive at 5 years	18	33.3	6	26	1	8.3	4	50

TABLE IV.—RELATION OF HISTOLOGIC TYPE TO END-RESULTS

Histology	Grade I		Epidermoid Grade II		Grade III		Melanoma		Basal cell carcinoma	
	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent
Number of cases	15		51		6		14		5	
Alive at 2 years	13	86.6	22	43.1	2	33.3	6	42.8	4	80
Alive at 5 years	9	60.0	11	21.5	1	16.6	2	14.2	3	60

seed implantation into the nodes. Only 1 (5.5 per cent) of this group survived 5 years and 1 died as a result of the radiation. Half of this group had enlarged nodes on original examination. The one successful case was in a patient whose nodes were deemed enlarged and suspicious of containing cancer.

Location and its effect on end-results. The site of origin of the disease cannot always be made with great accuracy because of the contiguity of the structures and because the growth shows extension in all directions. Nevertheless, we were able to determine the localization of the disease with a fair degree of accuracy in most cases. Of 223 cases tabulated, 133, or 59.6 per cent, originated on the labia majora; 47, or 21 per cent, on the labia minora and vestibule; 27, or 12.1 per cent, on the clitoris, and 13, or 5.8 per cent, on the posterior commissure and perineal body. There were 2 cases of Bartholin gland origin; also 1 on the mons veneris and one of the urethral meatus.

Table III shows the survival percentages of the primary group when divided according to site of origin. It has been our impression (and others, 16) that lesions of the clitoris are more virulent than those situated elsewhere. Although the number of cases is small, the figures substantiate this impression.

Histology and its effect on end-results. In Table IV we have listed, according to histologic type, the 5 year cure rate of the primary group of cases. As would be expected, the melanomas have the lowest number of survivals. One of the two 5 year survivals with this type of lesion died of disease at 7 years, and, although the other successful case had inguinal nodes positive for metastatic disease, the outlook for most patients with this type of histology is very poor. Because of this, we advocate removal of nearly all pigmented tumors in this region.

Of the 5 patients with basal cell carcinomas, 2 did not survive 5 years. However, 1 of these patients died of another cause, entirely unrelated to her cancer. Basal cell cancers, as is known, are of a less virulent nature and tend to recur rather than metastasize, but because of the exceedingly dangerous character of any cancer in this region, we feel that vulvectomy and not so called wide local excision is the method of choice. These cancers do metastasize although not, of course, with the frequency of an epidermoid lesion. In Wilson's report of basal cell carcinomas in his own patients and those collected from the literature, 36 per cent died before reaching the fifth year.

The prognosis of the low grade epidermoid tumors appears, from our series, to be approximately the same and undoubtedly is due to the vigorous form of treatment given a relatively weak lesion. The figures are too small for comparison of the grade II lesions with those of a more anaplastic type. It is our clinical impression, however, that most tumors more differentiated than grade I have a fairly similar clinical course. There was 1 patient with dermatofibrosarcoma protuberans of the vulva who is alive and well over 5 years.

SECONDARY GROUP

The patients falling into this classification were followed separately and analyzed in an identical manner. Treatment of patients was the same throughout. In general, the survival times for this group are similar to those of the primary; this is especially so as regards overall 5 year cure rates (Table I). Of 16 patients in class 1A (lesion localized to the vulva clinical-

ly), 7 or 43.7 per cent survived 5 years; this is a somewhat higher figure than in the primary group. Of 9 patients whose nodes were "suspicious" or thought to be enlarged (class 2A) but not dissected, only 1 (11.1 per cent) patient survived 5 years.

Fifteen patients fell into class 2B (positive inguinal nodes) and of this number 3 or 20 per cent survived 5 years; this, too, is slightly better than the other group. In 2 of these successful cases the groin dissection performed was unilateral. All of these dissections were of the superficial type. Four other patients had Basset type of dissections, 2 unilateral and 2 bilateral, but no patient survived more than 3½ years. Treatment with x-ray and radium gave equally poor results. When analyzed as to location, lesions on the clitoris and labia minora seemed most virulent, but the number of patients involved is small. Histologic types likewise showed no variation from the primary group; there was only 1 patient with basal cell carcinoma and she died of cancer in 3½ years.

In comparing the two large groups the similarity of end-results is evident. This is so despite the fact that the secondary cases received treatment elsewhere and were treated by us in what we may assume is a later stage of the disease. In some cases, therefore, it would seem that there is a favorable period in which the disease is amenable to therapy, but once beyond this point, no treatment appears successful.

COMMENT

It is needless to point out the marked difference between the early, low grade lesions and those which have become metastatic and invasive. After studying groups of patients, it becomes apparent that those who have received more vigorous and prompt treatment do better. Vulvectomy with at least a bilateral superficial groin dissection should be done in all cases adequate for surgery. Firm basis for this is seen in the high percentage of survivals (80 per cent) in the group with negative nodes (1B) where this was done, and the relatively poor showing (47.6 per cent) of the group (1A) where only vulvectomies were done because the nodes were *thought* to be negative at the time.

Our experience with the Basset type of groin dissection is still too young for definite opinion. Empirically, one is always justified in removing all areas to which the disease may spread, but it is somewhat questionable if in this condition, removal of cancerous iliac nodes changes the prognosis. In Taussig's (15,16,17, 18) series, this type of dissection was done in a large number of patients but only 48.4 per cent of his operative cases had nodes positive for carcinoma and we do not know whether the inguinal nodes alone or the inguinal and iliac nodes together were involved. If the former circumstance exists, a groin dissection as done by us in the series just reviewed should remove all positive nodes in this region. It would not, of course, remove any more highly placed metastatic deposits, removal of which, theoretically at least, may give a higher survival rate.

We have no way of telling from our series whether excision *en masse* (i.e., groins and vulva together) or in stages, as practiced by us at present, is the procedure of choice. Certainly a high percentage of patients in this age group are not ideal surgical risks and a two or three stage procedure may be tolerated with less difficulty.

Because of the very malignant nature of melanomatous lesions of the vulva, it seems that removal of all pigmented tumors in this area is the only safe course to follow. As it is impossible to tell when a neuronevus or pigmented mole will begin to show cancerous change, its local excision before this eventuality removes the threat which is ever present.

SUMMARY

Two hundred and twenty-eight cases of cancer of the vulva were studied. The condition is most prevalent during the seventh decade; over half the patients experienced pruritus, and more than 80 per cent of the lesions were of the epidermoid variety. The melanomas showed the lowest survival rate.

One hundred cases form the basis for the report of 5 year cure rates. Best results were obtained when a vulvectomy and bilateral groin dissection, without removal of the iliac nodes, was performed. When the disease extends to the inguinal lymph nodes, the prog-

nosis is markedly altered. The overall absolute 5 year cure rate was 26.00 per cent.

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MEDULLARY NAILING OF FRACTURES OF THE LONG BONES

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THE treatment of fractures of the long bones by means of medullary nailing was introduced by Kuentscher in 1940. During the war the procedure was used rather extensively in Germany, and there are numerous reports on the subject in German literature. Boehler (2), in 1944, after studying the histories of more than 500 patients and over 10,000 x-ray films, published a book on medullary nailing. The treatment has also been discussed to some extent in South American literature, and Jimeno-Vidal and Guttner reported on approximately 100 cases. No reports on the use of medullary nailing by surgeons in this country have yet appeared, although a few foreign reports have been reviewed in our literature (3, 8, 9). The treatment has interesting possibilities, and this preliminary report on an adaptation of the method in the treatment of 7 fractures is presented with a view to provoking discussion.

In principle, the Kuentscher method consists of introducing a long metallic splint through the medulla of both fragments. The splints are constructed of V2A[1] steel and are bilaminar and V-shaped in cross-section. They are made in different sizes and lengths. The nail is introduced at a distance from the site of the fracture. Its upper end, which is perforated, remains outside the bone, permitting the removal of the nail after healing has been established.

In the cases reported herein, nails made of tantalum were used, which is a nonelectrolytic metal and free from the flaws in metals requiring casting. The technique consisted of first opening the site of fracture and cleaning the ends of the fragments. The nail was introduced into the proximal fragment, then the fragments were approximated and the nail was directed into the wound and driven into the medulla of the distal fragment. With increasing study of this method it has seemed that a nail with a slight curve would provide for greater leverage and better immobilization than would the straight nail.

Medullary nailing has several advantageous features. It ensures the prompt establishment of absolute immobilization. The adjacent joints, however, remain free, permitting motion to be started promptly. Because of the complete fixation, ambulation or use of the extremity is possible at a surprisingly early date. It is particularly impressive to see a patient with a fracture of the mid femur walking with the aid of crutches in less than 3 weeks after the reduction. No supportive apparatus or plaster cast is necessary. Patients with fractures of both bones of the lower leg can walk in less than 2 weeks. A patient with a fractured humerus has good use of the arm in less than 2 weeks. Such early motion obviates the sequelae of rigidity, circulatory disorders, and atrophy from disuse. Because of the complete immobilization, the patient is free from pain. When the patient is elderly, the advantages of early motion are obvious.

The indications for medullary nailing are still not well defined. During the war it was used in Germany in treating fresh fractures of the femur, tibia, humerus, elbow, radius, and clavicle, as well as in cases of pseudarthrosis, but there is still no authorization for such wide application of the procedure. Boehler (2) concluded from his intensive study that only a limited number of fractures are suitable for medullary splinting, and that the best results are obtained in transverse and short oblique fractures above the middle of the femur. Boehler (2) recognized definite contraindications in fresh open fractures of the leg, in infected fractures, and in fractures in children. On the other hand, Ehalt used the method principally, and with success, in open fractures of the lower leg.

From the MacAusland Orthopedic Clinic.

[1]Special steel manufactured in Germany.

Fig. 1, left. M. B. The original fracture with medial displacement of the distal fragment.
Fig. 2. M. B. Roentgenogram taken 9 weeks after medullary splinting.

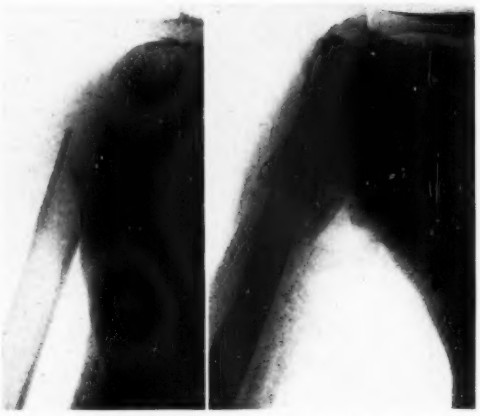

Fig. 3, left. A. M. Roentgenogram showing comminuted fracture with displacement following unsuccessful attempt at open reduction with screw fixation.
Fig. 4. A. M. Roentgenogram taken 6 months after medullary splinting showing solid union.

At the present time, the method seems suitable for selected cases. Whether its field of application will broaden with more extensive use remains to be determined. The procedure offers a solution for the treatment of simple fractures of the femur that are situated just below the greater trochanter, in which it is difficult to overcome and control the medial displacement of the distal fragment. Also, comminuted fractures in this area, which ordinarily require long surgical procedures for fixation by plates, are suited for the medullary method. Indications may be recognized in slanting and comminuted fractures of the upper end of the humerus that are difficult to treat. The method may be considered in treating fractures of both bones of the lower leg at the junction of the mid third which, under other forms of treatment, may require prolonged immobilization that prohibits early motion at the ankle joint, and in which nonunion may occur if the fragments are not perfectly aligned.

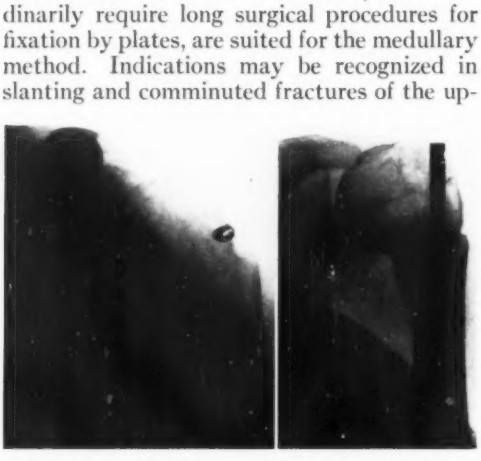

Fig. 5, left. M. S. Roentgenogram showing refracture of the humerus with angulation.
Fig. 6. M. S. Roentgenogram taken 3 months after medullary nailing, showing callus formation.

There are several features of the method of medullary fixation that have come under discussion. The question is raised as to the danger of infection from introducing a long metallic splint into the medullary canal. German operators claim that such danger is minimized by the insertion of the splint at a distance from the site of the fracture. In the 7 cases reported herein in which the fractures were opened, no infection was encountered. The routine use of penicillin, of course, minimizes such danger.

The advisability of using the method in open fractures has been discussed. Some operators, as Boehler (2), believe that its use is limited in these fractures; other operators, as Ehalt, have reported excellent results in open fractures. In 1 of the cases included in this paper, the fracture was an open one in which a fragment had protruded for as much as 6

Fig. 7. Fig. 8. Fig. 9.

Fig. 7. C. N. Roentgenogram of the original fracture showing the protrusion of the proximal fragment through the wound.
Fig. 8. C. N. Roentgenogram taken immediately after medullary nailing.
Fig. 9. C. N. Roentgenogram taken 3 weeks after medullary nailing, showing callus formation.

inches outside the wound for a period of more than 6 hours before the medullary splinting. There was no unfavorable reaction following the fixation.

The necessity of the removal of the splint is another question that may be raised. Most patients prefer to have foreign material removed. When tantalum is used, the removal of the splint may not be considered necessary.

Whether callus formation takes place earlier with consequent accelerating of the healing process, as Kuentscher and other operators have claimed, has been much debated. Boehler (2), Schneider, and Swiss operators (1) have noted that the development of callus was slow, and Boehler found that nonunion not infrequently resulted. It would naturally be concluded that callus formation would be stimulated as the result of the complete and uninterrupted immobilization provided by this method. In 1 of the 7 cases being reported, which was a fracture of both bones of the lower leg, the appearance of callus in the third week after medullary fixation was particularly striking (Fig. 9).

CASE REPORTS

Case 1. M. B., a woman aged 78 years, sustained a fracture of the right femur on September 4, 1945. The roentgenographic examination disclosed a fracture at the junction of the middle and upper thirds, with medial displacement of the distal fragment and about 1½ inches of overriding of the fragments (Fig. 1).

On September 11, 1945, a medullary nailing was carried out according to the following technique: An incision was made, beginning just above the greater trochanter and extending downward to about 2 inches below the site of the fracture. The greater trochanter and fracture cavity were exposed, and the blood clots and torn tissues were removed. A drill hole was made in the greater trochanter and enlarged by introducing a curved hemostat. The medullary nail was inserted into the medulla of the proximal fragment and driven through to the fracture site. The fragments were aligned. The nail was then driven into the medulla of the distal fragment. The deep tissues were closed with chromic catgut, and the skin was closed with silk. A roentgenogram was taken to check the position.

The disorientation of the patient made it necessary to place the limb on a Braun's splint and apply 5 pounds of traction. Movement of the ankle joint and toes was begun on the day following the operation. In 1 week when the patient's mental condition had improved, the splint was removed, and she

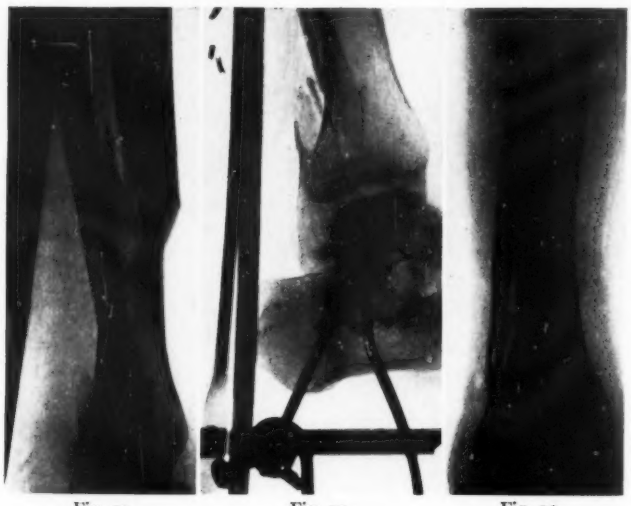

Fig. 10. Fig. 11. Fig. 12.

Fig. 10. A. G. Roentgenogram of the original fractures of the tibia and fibula.

Fig. 11. A. G. Roentgenogram showing unsatisfactory treatment of the fractures by skeletal traction.

Fig. 12. A. G. Roentgenogram taken following medullary splinting.

began to exercise the hip and knee freely and without pain.

From that time recovery was rapid. Within 3 weeks she was walking with the aid of crutches. A roentgenogram taken on November 14, 1945, shows the callus formation in 9 weeks after the medullary splinting (Fig. 2).

CASE 2. A. M., a 79 year old male, fractured the right arm on March 15, 1945. The roentgenographic examination showed a comminuted fracture of the upper humerus with displacement. Several unsuccessful attempts were made to reduce the fracture by manipulation. On March 18, 1945, an open reduction with screw fixation was carried out without success (Fig. 3).

On April 5, 1945, a medullary nailing was carried out according to the following technique: An incision was made to expose the fracture cavity and the upper end of the humerus. A drill hole was made in the humeral head and enlarged by means of a curved hemostat. A medullary nail was introduced into the medulla of the proximal fragment, the fragments were approximated, and the nail was driven through the distal fragment. The wound was closed, and the position of the fragments checked by a roentgenogram.

Within 2 weeks the patient was using the arm and had no complaint. Union took place rapidly. A roentgenogram taken on October 11, 1945, 6 months after the medullary nailing showed solid union (Fig. 4). The patient refused to consider the removal of the splint.

CASE 3. M. S., a woman aged 25 years, refractured the upper end of the humerus on December 23, 1945. She had previously fractured the humerus on August 19, 1945. The site of the fracture was in the upper end just below the tuberosity. At that time the fracture had been treated conservatively by another physician. Union was slow, and a roentgenogram taken on December 20, 1945, showed a slight amount of callus with angulation of the fragments. Figure 5 shows the refracture with a 40 degree angulation that caused a noticeable protuberance on the anterior aspect of the shoulder.

On December 28, 1945, a medullary nailing was carried out according to the technique that has been described under Case 2.

Motion was started at the elbow and shoulder on the twelfth day after the operation. In less than 3 weeks after the reduction, all motions were normal except abduction of the shoulder, which was limited 25 degrees. The patient had returned to work. Fourteen weeks after the reduction, abduction was limited 10 degrees, but this limitation was due to the protruding end of the splint hitting against the acromion. Removal of the splint was advised. A roentgenogram taken on April 2, 1946, shows the union (Fig. 6).

CASE 4. C. N., a 9 year old child, on March 1, 1946, in a coasting accident, sustained a compound fracture of the right tibia and fibula. The fracture was of the spiral type, and the proximal fragment protruded through a lacerated wound for about 6

inches (Fig. 7). It was 6 hours before the fracture was operated upon.

Medullary fixation was carried out as follows: A thorough débridement was performed, and the fractured ends were cleaned. The medullary splint was introduced into the medulla of the proximal fragment of the tibia, the fragments were aligned, and the splint was driven into the medullary canal of the distal fragment. The wound was closed (Fig. 8). Penicillin was advised.

On March 14, 1946, 2 weeks after the reduction, the patient was walking with the aid of crutches. She had no pain. The temperature was normal. A roentgenogram taken on March 21, 1946, 3 weeks after the reduction, showed callus formation (Fig. 9).

CASE 5. A. G., a male aged 51 years, fractured both bones of the lower leg on February 27, 1946. The fractures were of the spiral type with comminution, and the distal fragment of the fibula was displaced posteriorly (Fig. 10). Reduction was attempted by another physician by the use of skeletal traction with a Steinmann pin through the os calcis, but the result was unsatisfactory (Fig. 11).

On February 28, 1946, medullary nailing of both the tibia and fibula was done (Fig. 12). The splint was introduced into the fibula from the distal end.

In addition, 1 other subtrochanteric fracture of the femur and 1 comminuted fracture of the upper end of the humerus have been treated by medullary nailing. The rapidity of recovery of motion and functional capacity has paralleled that in the cases described.

SUMMARY

A series of 7 fractures of the long bones which were treated by an adaptation of the Kuentscher medullary splinting method has been reported.

The method is still in its infancy, and many of its features are under discussion. Indications for its use are not yet well defined, but it would seem to offer a solution of treatment for certain selected fractures. The method has the great advantage of providing for absolute immobilization yet at the same time leaving the adjacent joints free, thereby making possible the use of the extremity at a surprisingly early date.

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TOTAL CYSTECTOMY BY THE COMBINED PERINEOABDOMINAL METHOD

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EXPERIENCE has shown that surgical excision offers the best hope for the cure of infiltrating carcinoma of the bladder. If the neoplasm is confined to the dome or to the movable walls and is not too extensive, partial resection of the bladder may suffice. On the other hand, if the carcinoma involves the trigone and region of the vesical neck or if the tumors are multiple, removal of the entire bladder, prostate, and posterior urethra is often the only effective procedure.

In 67 cases of partial bladder resection, Beer and Hyman (3, 7) reported an immediate operative mortality of over 25 per cent, and a recurrence rate of at least 32 per cent. Eight additional patients died eventually of carcinoma. These results clearly indicate that partial resection is frequently not sufficiently radical; carcinoma cells often infiltrate in the submucous layers of the bladder far beyond the apparent limits of the growth. The occult nature of these infiltrations unfortunately deludes the surgeon into believing that an adequate resection has been done. Such was the case with L. G. (Beth Israel Hospital No. 165289) in whom a solid neoplasm was excised from the left lateral wall with a generous surrounding rim of apparently normal bladder. However, biopsies from the edge of the seemingly normal bladder wall, still in the body, revealed carcinoma in the submucosa. This patient was reoperated upon; a total cystectomy and prostatectomy were done.

Pioneers in the field of total cystectomy have reported an operative mortality of from 18 to 59 per cent (3, 6, 11). This alarming prospect has deterred many urologists from ever attempting the operation. However, improved technique, earlier operation, and the use of sulfa drugs have greatly reduced the operative risk. In the series forming the basis of this report, 15 total cystectomies were done without an operative death.

In the first 8 cases operation was done by the Beer technique (4) in which a total cystectomy and partial prostatectomy (6 men) were done extraperitoneally through a suprapubic abdominal incision, with cutaneous implantation of the ureters, in 1 stage. Although the patients withstood the operative procedure rather well, they subsequently all had a good deal of trouble with the care of their ureterostomy tubes, leakage of urine, recurrent attacks of pyelonephritis, and calculus formation. The carcinoma was well advanced in most of the patients, 4 having previously undergone less radical bladder operations. Ultimately, 3 patients died with metastases, the other 5 succumbing to renal infection and uremia. The outlook following total cystectomy with cutaneous ureteral implantation is certainly far from encouraging. No patient lived much over 2 years or was able to lead a comfortable normal life.

The unsatisfactory results following cutaneous ureterostomy have encouraged us, whenever possible, to implant the ureters into the sigmoid colon, especially since the advent of sulfasuxidine and the other sulfa drugs. Following successful ureterosigmoid implantation, our patients have lived a comfortable normal life, voiding through the rectum with control.

Infiltrating carcinoma in the region of the trigone and the bladder neck not uncommonly invades the prostate and the posterior urethra. Therefore, any operation intended for the cure of such a lesion must be designed to extirpate completely, in one piece, the unopened bladder with the entire prostate, both seminal vesicles, and the posterior urethra. In the female, the suprapubic abdominal approach is usually adequate for a total excision of the bladder along with a generous portion of the urethra. In the male, on the other hand, the

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suprapubic approach fails because partial prostatectomy is usually done (2, 3), thus leaving a stump of prostate and urethra which may be the seat of carcinoma. Such was the case in S. P. (Montefiore Hospital No. 34945), in whom residual neoplasm was found in the posterior urethra and in the prostatic stump after a suprapubic total cystectomy. This patient subsequently died with multiple metastases.

The perineal approach to the bladder neck and prostate, proposed by Kuester (1) and employed by others (2, 9, 12), when it is combined with a suprapubic incision, permits a truly radical extirpation of the unopened bladder with the entire prostate, both seminal vesicles, and posterior urethra in 1 piece (Figs. 5, 6, 7, 8). The perineal incision simplifies the mobilization of the urethra, prostate, and bladder neck, and affords excellent dependent drainage.

The operation is done in 2 stages. Prior to each, the patient is prepared with sulfasuxidine, colonic irrigation, and cathartics. At the first stage, the right ureter is implanted extraperitoneally into the sigmoid colon by the Coffey 1 or 2 technique (5, 8). At the second stage, total cystectomy, total prostatectomy, bilateral seminal vesiculectomy, and posterior urethrectomy are performed by the combined perineoabdominal method, and the left ureter is implanted into the sigmoid colon.

TECHNIQUE FOR THE COMBINED PERINEOABDOMINAL OPERATION

1. Perineal incision. With the patient in the exaggerated lithotomy position and a Lowsley prostatic tractor in the bladder, an inverted U incision is made through the perineal skin (Fig. 2). The central tendon is identified and divided. The exposed fibers of the rectourethralis are cut, separating the bulb from the rectum. The glistening fascia of Denonvilliers is brought into view, and its posterior layer incised transversely, exposing the apex of the prostate and the urethra. The posterior leaf of Denonvilliers' fascia is then bluntly separated from the posterior surface of the prostate, seminal vesicles, and bladder as high as the finger can reach. The urethra is isolated, doubly tied, and divided, as far anteriorly as desired (Fig. 3). The ligated proximal stump of the urethra is then drawn downward exposing the anterior surface of the prostate and bladder (Fig. 4). The puboprostatic ligaments are brought into view and cut along with other adhesions.

At this stage the trigone, the vesical neck, the prostate, the seminal vesicles, and the posterior urethra have been mobilized and hang attached only to the upper portion of the bladder (Fig. 1). Bleeding vessels are tied, and the perineal skin is approximated by interrupted plain catgut sutures, with a soft rubber tube for drainage.

2. Suprapubic abdominal incision. With the patient flat on his back in moderate Trendelenburg position, a wide transverse skin incision is made about 3 centimeters above the symphysis pubis. The anterior rectus fascia and the fascia of the external oblique are cut transversely the full length of the incision. The rectus muscles are bluntly separated in the midline and retracted laterally. In some cases, part of the pubic insertion of the rectus must be severed in order to obtain adequate exposure. The dome of the bladder is then separated from the peritoneum by sharp and blunt dissection.

The peritoneum is opened sufficiently for inspection and exploration and then closed with a continuous chromic catgut suture. The anterior, posterior, and lateral walls of the bladder are freed from the surrounding tissues by sharp and blunt dissection, the strands containing the various vesical arteries and veins being doubly tied and cut. The region of the bladder neck and prostate, already mobilized through the perineal incision, is soon reached. The bladder now lies free, attached only by the vasa deferentia and the ureters. These structures are isolated, doubly tied and cut, thus allowing the unopened bladder with its attached organs to be removed from the wound.

The ligated right ureter is left in place since its proximal portion has already been implanted in the sigmoid colon at the preliminary operation. The left ureter is implanted extraperitoneally by the Coffey 1 or 2 technique. The abdominal wound is closed in layers with the long through-and-through rub-

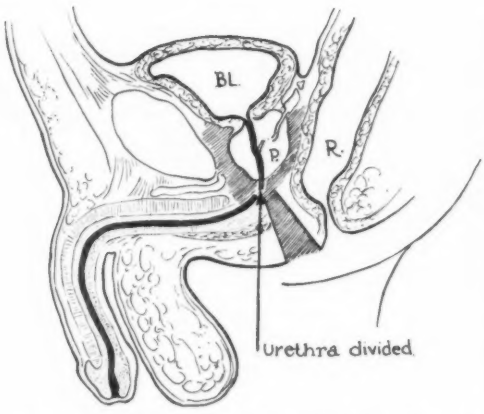

Fig. 1. Diagram showing the approximate extent of mobilization attained through the perineal incision.

ber drainage tube from the perineal wound coming out in the midline.

Five of the 6 patients operated upon by the perineoabdominal method with ureterosigmoid implantation, are living comfortably voiding through the rectum with good control. The remaining one (Case 12) suffered from an advanced carcinoma and died 5 months after operation with recurrent neoplasm filling the pelvis.

CASE REPORTS

Case 9. (Beth Israel Hospital Nos. 160261 and 161992). This 61 year old man entered the hospital on February 2, 1944, complaining of frequent painful bloody urination for the past 2 months. About 8 months before, he had undergone a 2 stage suprapubic prostatectomy.

Cystoscopic examination revealed a large tumor mass on the left lateral wall of the bladder, extending anteriorly and downward to the trigone, surrounding the left ureteral orifice. Biopsies disclosed carcinoma. Excretory urography on February 3 showed good excretion and no abnormality of the renal pelves and ureters. The cystogram showed an irregular filling defect on the left side of the bladder.

On February 5, 1944, a partial resection of the bladder was done. The excised specimen included the neoplasm with a generous cuff of apparently normal bladder wall surrounding it. Since the resected segment included the left ureteral orifice and part of the trigone, the left ureter was reimplanted in the posterior wall near the dome of the bladder. At the time of operation, biopsy specimens were taken from the normal-appearing edge of the trigone which remained *in situ*. These revealed submucous carcinoma and, therefore, total cystectomy and prostatectomy were advised.

On April 13, 1944, the right ureter was implanted extraperitoneally into the sigmoid colon by the Coffey 1 technique. On May 5, 1944, a total cystectomy, prostatectomy, seminal vesiculectomy and posterior urethrectomy were done by the combined perineoabdominal method. The left ureter was implanted extraperitoneally into the sigmoid colon by the Coffey 2 technique. The patient did well after operation, and left the hospital on May 21, 1944.

An excretory urogram on May 18, revealed excellent excretion of both kidneys with, however, some increase in the dilatation of both pelves and ureters. The patient improved steadily, gained weight, but voided frequently through the rectum. He complained of pain over the pubis, and, on August 1, 1944, re-entered the hospital for revision of a persistent draining suprapubic sinus. Biopsy of the tract showed inflamed tissue. The wound was packed and by December 1, was entirely healed. A short course of deep x-ray therapy was given to the pubic area.

Excretory urography on January 16, 1945, showed fair excretion from both kidneys with dilatation of the left ureter. Blood nonprotein nitrogen on April 17, 1945 was 46 milligrams per cent.

An excretory urogram on November 26, 1945, showed excellent excretion from both kidneys and normal outlines of both pelves. On May 14, 1946, the general condition was excellent, the patient's only complaint being frequent rectal urination.

Excretory urography on May 28, revealed excellent excretion from both kidneys and normal outlines of both pelves and ureters.

Case 10. (Beth Israel Hospital No. 161329.) This 56 year old man entered the hospital on March 16, 1944, complaining of frequent and intermittently bloody urination of 6 months' duration. On cystoscopic examination, an infiltrating, partly papillary, and partly solid tumor was seen on the right lateral wall, surrounding the right ureteral orifice and extending to the trigone and bladder neck. Repeated biopsies revealed papillary and infiltrating carcinoma. Excretory urography showed normal function of both kidneys and normal outlines of both renal pelves and ureters. The cystogram showed a filling defect on the right side of the bladder.

On March 25, 1944, the right ureter was implanted into the sigmoid colon extraperitoneally by the Coffey 1 technique. Fourteen days later, a total cystectomy, prostatectomy, seminal vesiculectomy, and posterior urethrectomy were done by the combined perineoabdominal method (Figs. 5, 6). The left ureter was implanted extraperitoneally into the sigmoid colon by the Coffey 1 technique.

The postoperative course was smooth except for a right epididymitis with chills. An excretory urogram on April 26, 1944, showed excellent function of both kidneys with moderate dilatation of the pelves and ureters. Another, on February 17, 1945, showed normal pelves and ureters and excellent function of

both kidneys. On May 4, 1944, the patient left the hospital in good condition, voiding every 2 hours through the rectum.

He re-entered the hospital on August 10, 1944, complaining of pain in the region of the pubis, groins, and thighs. Seven weeks before, the suprapubic wound had spontaneously opened with persistent purulent drainage. An x-ray film of the pelvis showed no evidence of metastasis. The wound was irrigated with Dakin solution and both sulfadiazine and penicillin were administered. Following a course of x-ray therapy to the pubic area, the pain abated and the purulent discharge diminished. The patient left the hospital improved on August 26, 1944.

He was again admitted to the hospital on December 10, 1944, for further revision of the suprapubic sinus and left 2 days later. He re-entered the hospital on January 15, 1945, suffering from lobar pneumonia. During this time, the wound was packed and irrigated and gradually healed except for a pinpoint sinus tract.

On June 8, 1945, there was moderate bulging of the suprapubic wound. The general condition was excellent, the patient voiding every 2 or 3 hours through the rectum, with good control.

The patient remained well and on September 15, 1945, the wound had practically healed. When last seen at the Follow-up Clinic on June 6, 1946, the patient had no complaints and was in good health.

Fig. 2. Perineal skin incision with tractor in place.

CASE 11. (Beth Israel Hospital No. 168686.) This 65 year old man first entered the hospital on December 8, 1944, complaining of frequent and painful urination for the past 9 months. He had noticed that his urine was cloudy and had for some time been treated with urinary antiseptics and prostatic mas-

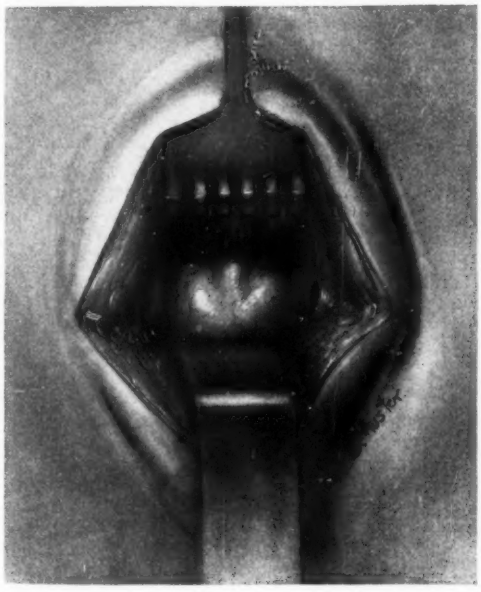

Fig. 3. The prostate is exposed prior to the mobilization of the urethra.

Fig. 4. Urethra tied and divided, thus exposing the puboprostatic ligaments.

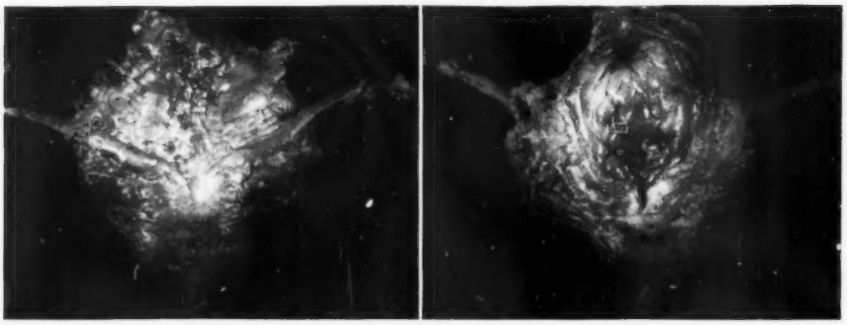

Fig. 5, left. Case 2. Posterior view of excised specimen, consisting of the entire bladder, the prostate, the posterior urethra, and both seminal vesicles with vasa deferentia.
Fig. 6. Case 2. Anterior view. Bladder has been opened.

sage. On December 7, cystoscopic examination showed a raised tumor mass, about the size of a half dollar, covered with slough, extending from the urethrovesical junction upward to the left posterior wall of the bladder. The first biopsy showed only inflammatory tissue, but a subsequent biopsy revealed carcinoma with severe inflammation. On excretory urography there was poor excretion from both sides but no gross abnormality of the kidney or ureter. The cystogram showed a marked irregularity of the inferior and left lateral border of the bladder.

On December 21, 1944, the right ureter was implanted into the sigmoid colon extraperitoneally by the Coffey 1 technique. The new stoma, however, failed to function, and no urine was excreted by the right kidney. A fecal fistula formed which persisted until January 10, 1945. On January 11, a right nephrostomy and decapsulation were done. There was a gradual return of renal function and the tube was draining well on January 23.

A total cystectomy, seminal vesiculectomy, prostatectomy, and posterior urethrectomy were done on February 3, 1945, with implantation of the left ureter into the sigmoid colon by the Coffey 2 technique. Pathological examination showed partly papillary and partly solid carcinoma. Following operation, urine drained through the rectum and through the nephrostomy tube. The patient continued gradually to improve, and on March 3, 1945, a retrograde pyelogram through the right nephrostomy tube revealed that the right ureter now communicated with the bowel. The patient was discharged to the Outpatient Department on April 4, 1945, with a functioning right nephrostomy.

On April 6, the right nephrostomy tube was closed for 3 days without ill effect, and on April 19, it was removed. On April 26, the wound was closed and healed. An excretory urogram, taken the following day, showed fair excretion from both sides; the pelves and calyces, partially visualized, were not dilated. There was a large amount of opaque material in the sigmoid colon.

By June 8, the patient had gained 20 pounds. He continued to improve remarkably, and when seen on November 3, 1945, had gained 33 pounds and was feeling well. Excretory urograms showed fair function of both kidneys. The patient voided through the rectum 3 times daily and once at night with good control.

When last seen, on May 18, 1946, the patient's condition was excellent.

Case 13. (Beth Israel Hospital No. 177388.) This 62 year old man was first seen on October 9, 1945, complaining of frequent bloody urination of 5 weeks' duration. Urination was hesitant and sometimes painful; the stream was small. Five years ago, a papillary tumor of the bladder had been electrocoagulated and since then the patient had had no symptoms until the present illness.

Cystoscopy revealed considerable enlargement of both lateral lobes of the prostate, intraurethrally and intravesically. On the surface of the intruding left lateral lobe, there was an elevated, irregular, reddened area which had the appearance of an infiltrating carcinoma. The neoplasm extended upward along the left lateral wall of the bladder and also anteriorly into the urethra, for a short distance.

The patient entered the hospital on October 11, 1945, and on the next day biopsies were made and a transurethral prostatic resection was done, the visible portion of the neoplasm being removed entirely. The pathological report showed extensive papillary and solid carcinoma invading the left lateral prostatic lobe. Tissue, removed from the right lateral lobe, showed only benign hypertrophy. Excretory urography showed fair excretion from both sides. The right pelvis and ureter were normal, but the left were incompletely visualized. The cystogram revealed irregularity of the right lateral wall and inferior surface of the bladder with some trabeculation.

The right ureter was implanted into the sigmoid colon extraperitoneally by the Coffey 2 technique, on October 19, 1945. Convalescence was uneventful and on November 1, a total cystectomy, prostat-

ectomy, seminal vesiculectomy, and posterior urethrectomy were done by the combined perineoabdominal method. The urethra was divided 3 centimeters distal to the apex of the prostate (Figs. 7, 8). The left ureter was implanted into the sigmoid colon by the Coffey 2 technique.

The postoperative course was smooth, and an excretory urogram made on November 23, 1945 showed excellent excretion from both kidneys with only slight dilatation of the left ureter. The patient left the hospital on November 25, 1945.

On January 16, 1946, the patient felt well, had gained over 20 pounds, and was voiding through the rectum every 2 or 3 hours, with good control. The perineal wound was healed, but a pinpoint sinus still remained in the midportion of the abdominal scar.

The wounds healed and the patient returned to work. On May 23, he was feeling well and voiding through the rectum every 2 hours. The blood nonprotein nitrogen was 36.7 milligrams per cent, and the patient had gained over 30 pounds since operation had been performed.

CASE 14. (Beth Israel Hospital No. 179761.) This emaciated 64 year old woman entered the hospital on January 9, 1946, complaining of hematuria of over 8 months' duration. At cystoscopy an infiltrating carcinoma was found, involving almost the entire trigone and extending upward on the right lateral and posterior walls. Excretory urography showed excellent excretion from the left kidney and none from the right. The lower left ureter was moderately dilated. A left nephrostomy was done on January 11, and 24 days later the entire bladder with an attached portion of the urethra was excised through a transverse suprapubic incision. Because of the precarious condition of the patient the left ureter was not implanted into the sigmoid colon, but was ligated *in situ* just above the bladder. The right ureter was reimplanted into the abdominal skin. On February 28, the poorly functioning infected right kidney was excised.

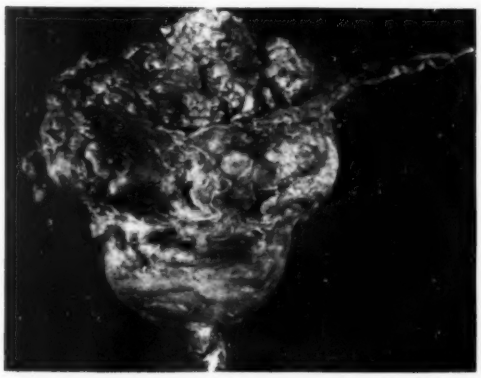

Fig. 7. Case 4. Posterior view of excised specimen consisting of the entire bladder, the prostate, the posterior urethra, and the seminal vesicles.

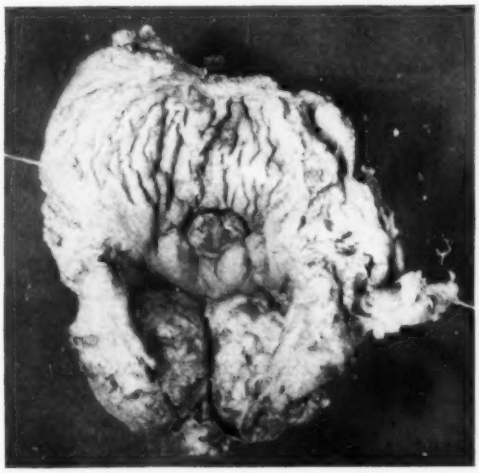

Fig. 8. Case 4. Anterior view of excised specimen. Bladder has been opened.

Following these operations, the patient slowly regained her strength and left the hospital on March 24, 1946, with all the wounds healed. The nephrostomy was functioning well.

On May 22, the patient had gained 8 pounds and was strong enough to do light housework. Physical examination failed to reveal any evidence of recurrence or metastases, and the left nephrostomy was functioning well.

CASE 15. (Beth Israel Hospital No. 181470.) This 57 year old man entered the hospital with an extensive infiltrating carcinoma involving the trigone and posterior urethra, and extending upward on the posterior and lateral walls of the bladder. On March 22, 1946, Dr. William Ginsberg and I implanted the right ureter into the sigmoid colon. Convalescence was satisfactory and on April 11, the entire bladder with an attached segment of infiltrated peritoneum, the prostate, the posterior urethra, and the seminal vesicles were excised by the perineoabdominal method. The left ureter was implanted into the sigmoid colon.

Following operation, the temperature was elevated and on the fifth postoperative day there was discharge of fecal material through both wounds. This gradually decreased in amount. Excretory urography on May 8, 1946, showed excellent excretion from both sides with mild dilatation of the right pelvis and ureter and normal outlines of the left pelvis and ureter. The patient left the hospital on May 27, 1946, in good physical condition, voiding through the rectum with normal control. A small fistula persisted which occasionally discharged fecal matter.

SUMMARY

Fifteen consecutive total cystectomies have been reviewed. There were no operative deaths.

In the first 8 cases operation was done through a suprapubic abdominal incision with bilateral cutaneous ureterostomy in 1 stage. None of these patients lived much over 2 years, nor did any lead a comfortable life after this operation. Three died with distal metastases or with residual neoplasm in the stump of the prostate and urethra; 5 succumbed to renal infection and uremia.

Six male patients were operated upon by the combined perineoabdominal method with implantation of the ureters into the sigmoid colon. Five of the 6 men operated upon by this plan are living comfortably, voiding through the rectum with normal control. The 1 remaining, an advanced case, survived the operations but died 5 months later with a large residual carcinoma.

The operation is done in 2 stages: at the first, the right ureter is implanted extraperitoneally into the sigmoid colon; at the second stage, the bladder, seminal vesicles, prostate, and posterior urethra are removed in 1 piece through a combined perineoabdominal approach, and the left ureter is implanted extraperitoneally into the sigmoid colon.

In males, the preliminary mobilization of the urethra, prostate, and bladder neck through the perineal incision simplifies greatly the subsequent suprapubic excision of the bladder.

The combined perineoabdominal method is recommended in men suffering from infiltrating carcinoma of the vesical neck and trigone because it permits a truly radical excision of the bladder together with the attached posterior urethra, the entire prostate, and the seminal vesicles.

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THE SPLIT THICKNESS GRAFT—A USEFUL ADJUNCT IN TUBE PEDICLE PREPARATION

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THE tube pedicle is subject to complications which may delay its use or destroy valuable tissue. The most common complications are infection due to excessive tension and hematoma formation. The answer to these serious problems is the use of split thickness graft in the donor site area, which relieves tension and also allows adequate tissue to be taken. There is no undermining necessary, thereby preventing hematomas. The purpose of this paper is to emphasize a method that will prevent the numerous difficulties that arise from the ordinary methods of tube formation.

Possible complications from tube pedicle formation are: (1) infection, which may be caused by (a) separation at angles, (b) separation of donor site suture, (c) wide undermining, (d) hematoma formation secondary to undermining, and (e) excessive use of suture material; (2) lowering of patient's resistance through loss of blood, shock and prolonged surgery, and greater morbidity due to enlarged operative field from undermining; (3) decreased blood supply and possible necrosis of tube due to undermining near each end of tube pedicle.

The prevention of infection in the tube determines its usefulness. The healing of each angle is extremely important in the use of any tube pedicle flap. These angles are necessarily dangerous and invite infection because of increased local tension at the junction of four contiguous suture lines. Circulation at the angle is embarrassed and the necessary sutures do little to improve this diminished blood supply.

Many have advocated various means to obliterate the dangerous angles, such as staggering incisions, and flap advancement beneath the tube. These techniques, ingenious as they may be, still call for undermining to close the donor site, and invite the complications listed.

The split skin graft over the donor site and beneath the pedicle prevents these difficulties and assures an intact angle. Angle separation

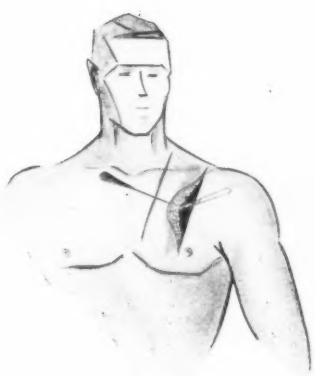

Fig. 1.

Fig. 1. Diagram showing lines of incision for neck-chest tube.

Fig. 2a.

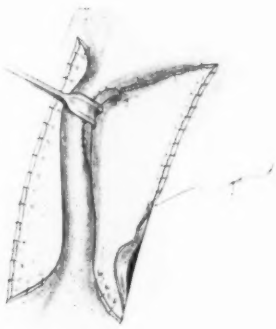

Fig. 2b.

Fig. 2. a, Closure of tube and suturing skin edges to fascia. b, Split thickness graft covering donor site.

Fig. 3.

Fig. 3. Diagram of technique of dressing. *1*, gauze roll to protect tube; *2*, mechanics' waste; *3*, xeroform gauze; *4*, gauze pressure pad to fit grafted area; *5*, split thickness dermatone graft; *6*, fat; *7*, adhesive dressing; *8*, skin.

Fig. 4.

Fig. 5.

Fig. 6.

Fig. 7.

Figs. 4 to 7. Defect of hand reconstructed by thoracoepigastric tube.
Fig. 4. Land mine injury.
Fig. 5. Thoracoepigastric tube, 10th day postoperative.
Fig. 6. Hand defect covered with tube flap. Note skin grafting donor site.
Fig. 7. End result—hand in flexion.

Fig. 8.

Fig. 9.

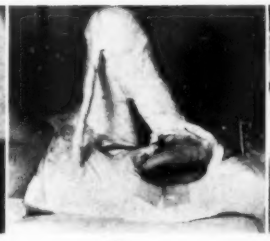

Fig. 10.

Fig. 11.

Figs. 8 to 11. Defect of foot reconstructed by thigh tube.
Fig. 8. Defect of foot (shrapnel wound).
Fig. 9. Thigh tube, graft beneath tube, flap after secondary delay.
Fig. 10. Attached tube flap to foot in cast (10th postoperative day).
Fig. 11. Defect covered by severed tube pedicle flap.

is eliminated because the graft produces countertraction at the angle and reduces tension at this danger point.

This graft technique (Figs. 1, 2, and 3) eliminates wide undermining which greatly jeopardizes the blood supply at the center of the tube. It eliminates the use of much heavy suture material to overcome lateral flap tension and approximation. With the former methods, one was limited in the width of the proposed tube by the need for enough skin laterally to reclose the donor site. When using a split thickness graft in the donor site, adequate tissue can be taken and still the donor site be closed with ease. The length of time necessary to close the resultant defect from the formation of a large tube must also be considered. In the routine tube preparation, when the donor site is closed, either with or without layer approximation, a thin wide tender scar results.

TECHNIQUE

The common sites used in this clinic are: abdominothoracic region, inner aspect of thigh, neck-chest, and upper arm. The pro-

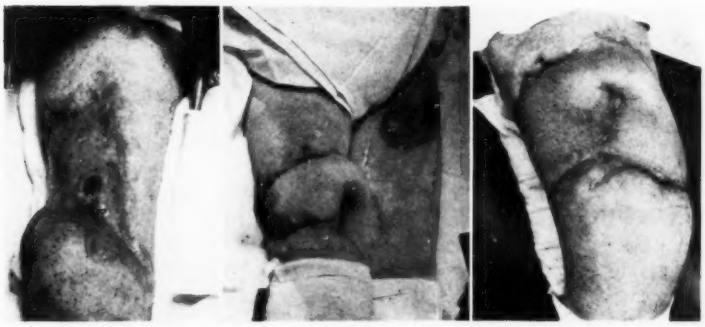

Fig. 12. Fig. 13. Fig. 14.

Fig. 15. Fig. 16. Fig. 17. Fig. 18.

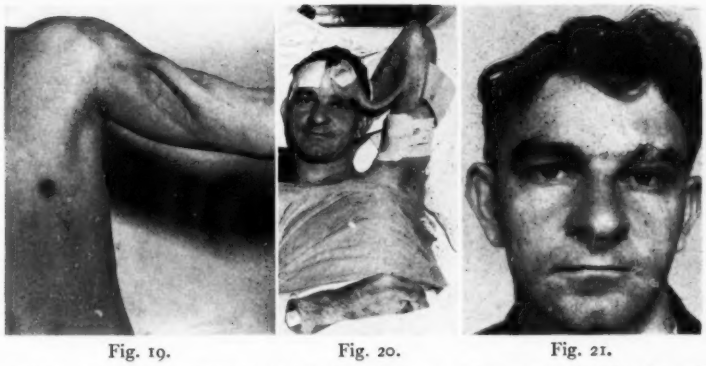

Fig. 19. Fig. 20. Fig. 21.

Figs. 12 to 14. Defect of thigh reconstructed by thigh tube.

Fig. 12. Defect of thigh.

Fig. 13. Transfer of tube pedicle flap to defect.

Fig. 14. Defect completely covered with tube pedicle flap.

Figs. 15 and 16. Covering stump of forearm to preserve length for prosthesis by large thoracoepigastric tube.

Fig. 15. Attached tube flap to forearm.

Fig. 16. Stump covered with tube pedicle flap.

Figs. 17 to 21. Defect of scalp covered by arm tube.

Fig. 17. Recurrent epithelium forehead (basal cell carcinoma).

Fig. 18. Split thickness graft to cover excision defect.

Fig. 19. Arm tube grafting of donor site.

Fig. 20. Tube pedicle flap attached to forehead.

Fig. 21. Defect completely covered with tube pedicle flap.

posed flap is undermined down to deep fascia between two parallel incisions which determine its width. One side at a time is undermined so as to determine the amount needed for a soft pliable tube in which there will be no tension on closure. If patient is obese, this is especially important and the procedure is relatively more difficult from beginning to end. The flap is then tubed until closure is prevented by slight tension at each end. The hemostasis must be as perfect as possible for upon this depends the success or failure of the procedure. Several interrupted subcuticular sutures are used, approximately 1 centimeter apart, to prevent dehiscence of the tube. Following this, the skin edges are approximated with interrupted sutures. The tube donor site skin edges are attached to the deep fascia with interrupted subcuticular immobilizing sutures. The graft is taken from any desired region, approximately .025 to .030 of an inch thick. The graft is sutured into position with a running locked suture, the graft edge being closed in direct approximation and not overlapping the surrounding skin. At each corner, direct tailoring of the graft is necessary, so that there will be no overlapping or folding of the skin, thereby maintaining normal skin tension. Xeroform gauze is cut to the shape of the graft pattern and laid directly upon the graft. A wet gauze stent pattern assures adequate pressure. Xeroform gauze is then placed above the stent to protect the suture line of the tube. The dressing is held in position by strips of sterile adhesive or Scotch tape which will run beneath the tube and across the thigh to maintain the desired pressure. Two additional strips crossing beneath the tube diagonally hold pressure at each corner of the graft. Beneath these we have found it advisable to place small triangles of gauze stent so as to give additional pressure at each angle of the graft. Following this, two rolls of gauze slightly larger than the tube itself are placed parallel to it on each side, to give additional pressure to the graft and prevent any constriction across the center of the tube which might cause necrosis in this region. An overall immobilization dressing is used for final protection. A window may be made through the dressing to permit inspection of the tube as frequently as indicated to assure oneself that there is no embarrassment of the circulation at its center. The dressing is done on the sixth to the tenth day.

CONCLUSION

The technique which uses a split graft beneath the donor site is described. It has been used routinely for all tubes except those of the neck. The tubed pedicles so prepared show rapid healing and few complications.

GANGLIONEUROMA OF THE SYMPATHETIC NERVOUS SYSTEM

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TUMORS composed of sympathetic ganglion cells and sheathed neurites with or without myelin have been well known for at least 76 years, since Loretz in 1870 described one which grew in the mediastinum. During that time cases have gradually accumulated until now there are more than 250 on record. Without making an exhaustive search, the writer has been able to find available reports of 233 patients in the literature and to assemble 10 additional unpublished cases. A study of these furnishes a great deal of information yet even now it is impossible to gain an entirely comprehensive conception of this interesting tumor form because of the extreme paucity of follow-up data. In all these reports I could find only 6 in which the case had been followed more than 3 years after removal of the tumor (14, 19, 25, 40, 64, this series Cases 1 and 3), and 4 more in which the tumor was known to have been in existence for more than 3 years without removal (11, 24, Glinski, 115). This paucity of information regarding the curative value of operation is all the more lamentable when it is realized that attempts at removal or operative explorations have resulted in at least 21 postoperative deaths, 11 intra-abdominal tumors (2, 5, 10, 51, 59, 71, 83, 88, 106, 116, 117), 9 mediastinal tumors (49, 12, 20, 23, 26, 27, 30, 62, 114, Case 2), and 1 neck case (75). If attempts at removal of these deep seated tumors are so hazardous, it would be extremely valuable to have accurate data about the results of removing them both when they are excised in whole or in part and when they are not treated at all. What little information exists will be considered here but it is so incomplete that it is indecisive.

The anatomical distribution of these tumors is shown in Table I. It confirms the general impression that the commonest sources of origin are the great chains of sympathetic ganglia which extend from the base of the skull into the pelvis passing through the neck, posterior mediastinum, and the retroperitoneal regions including the suprarenal medulla. It also shows that on occasion the smaller sympathetic ganglia in a variety of situations can give rise to these tumors, but that this is an event of extreme rarity. No doubt as time passes it will be found that they can arise in other places not mentioned here. This paper records for the first time finding them attached to the spermatic cord (Case 3) and in the tongue (Case 11). Other solitary examples in bizarre situations are reported by Bertini in the stomach, Lages Netto in the breast, Foster in the knee joint, Jorge and Latienda in the maxilla, Cramarossa, Fingerland and Sikl, Meyer, Rindfleisch in the uterus, and questionable cases in the vulva by Lovelady, McDonald, and Waugh, and in the kidney by Wright. Rarely they are associated with von Recklinghausen's disease (40, 66, 95, 120, 115, Case 12). There are a few examples with multiple tumors in the skin which may also be unusual varieties of von Recklinghausen's disease (58, 60, 81, 112). Askanazy found a case with multiple peritoneal tumors. When these tumors involve the intestinal tract or appendix they may be diffuse proliferations which cause a giant overgrowth of a whole portion of it. This has been described by Jentzer and Fatzer, Masson, Martínez-Gutierrez, Pick, Pick and Bielchowsky, Poate and Inglis, Oberndorfer, and Schultz. These tumors are not limited to man for Thomas has reported one in a codfish.

Table II shows that 60 per cent of these tumors are found before the age of 20 years with the greatest concentration in the first decade of life. Females predominate over males in the proportions of 3 to 2. Contrary to the impression gained by the earlier writers as expressed by Coenen there is no preponder-

From the Surgical Pathology Laboratory of the College of Physicians and Surgeons, Columbia University, and the Department of Surgery, Presbyterian Hospital, New York.

TABLE I.—ANATOMICAL DISTRIBUTION OF 243 CASES OF GANGLIONEUROMA OF THE SYMPATHETIC SYSTEM

Location	No. cases
Neck	24
Mediastinum	62
Abdomen:	
Lumbar	44
Pelvic	32
Suprarenal	31
Mesentery	5
Peritoneum	1
Appendix	6
Intestine	3
Stomach	1
Ovary	6
Uterus	4
Kidney	1
Total	134
Skin etc.	8
Orbit and lids	4
Pharynx	1
Larynx	1
Tongue	1
Spermatic cord	1
Leg	2
Breast	1
Vulva	1
Generalized	3

ance of tumors on the left side. The figures show no significant difference between the two sides.

The deep seated ganglioneuromas not infrequently grow to a relatively large size as exemplified by the retroperitoneal tumors reported by Zagarese which weighed 6.25 kilograms and measured 54 by 42 centimeters and one described by Peters in a 3½ year old boy which weighed 6 kilograms and measured 20 by 40 centimeters. Almost all of them are solid although the tumor reported by Jentzer and Fatzer was partly cystic.

The tumors generally are circumscribed and often encapsulated but their stubborn persistent growth not infrequently causes them to surround or become intimately bound up with important structures like the aorta and vena cava or insinuate themselves through foramina into the spinal canal (2, 18, Case 2, 30, 32, 37, 57, 62, 90, 96, 115, Case 2). When such events take place, the chances of complete removal are remote.

While a majority of the tumors are definite encapsulated neoplasms, there occurs occasionally a growth which looks more like a hyperplasia of a normal ganglion. An example of

TABLE II.—VITAL STATISTICS OF CASES OF SYMPATHETIC GANGLIONEUROMA

Age years	Per cent	No. patients
0–9		69
10–19		43
20–29		30
30–39		20
40–49		5
50–59		10
60–69		5
70–79		4
80–89		1
Mean age, 20 years		
Below mean age	60	112
Males	41.75	76
Females	58.25	106
Right side		60
Left side		50
Fully differentiated		146
Metastases		0
Partly differentiated		53
Metastases	36	19

this is furnished by Case 11 (Fig. 10). This growth was sufficiently large to produce a clinical swelling in the tongue, yet the sections show only what appears to be an unusually large sympathetic ganglion in a circumvallate papilla. This is analogous to a similar swelling in the appendix which projected into the lumen and was reported by Lichtenstein and Ragins and to tiny nodules in the hilus of the ovary described by Joachimovits, Meyer, and Neumann and in the uterus by Fingerland and Sikl, Meyer, and Rindfleisch. The cases of diffuse ganglioneuromatosis of the intestine and appendix (74, 76, 87, 94) are no doubt more diffuse examples of the same process. Since it has been demonstrated by Murray and Stout that adult ganglion cells both normal and neoplastic can multiply readily *in vitro* by mitosis, there is no reason to be surprised that both ganglion cell hyperplasia and ganglioneuroma can develop *in vivo*.

These tumors do not seem to give evidence either of hormonal activity nor of its suppression. Lunghetti and Coccheri's 61 year old man with a differentiated ganglioneuroma in the right adrenal died with anemia and skin pigmentation suggestive of Addison's disease. It is hard to understand any relation between the two. Jergesen's patient, a 23 year old male, suffered from right side paralysis, inability to urinate, pain in the left arm, blindness in the left eye, tinnitus and a blood pressure fluctuating from 250/120 to 274/140. He

died 9 weeks after onset of symptoms. At autopsy a 4 centimeter encapsulated, yellowish-brown tumor was found near the lower pole of the left kidney. The microscopic description states that there were cells in the tumor resembling spinal ganglion cells but the photomicrograph looks more like a phaeochromocytoma. None of the other authors has recorded any features suggestive of hormonal activity.

One feature of these tumors which has excited much curiosity has been the enormous numbers of neurites present in comparison with the much smaller number of ganglion cells. An often expressed hypothesis was reiterated as recently as 1934 by Scherer. This would have us believe that the axis cylinders can persist indefinitely after the death of the mother cell although there does not exist an iota of credible data in support of it. Ribbert tentatively made the suggestion that perhaps the neurites were inordinately long or had frequent branches. He also mentioned without supporting it the old and now abandoned hypothesis that neurites can be manufactured by Schwannian cells. This writer subscribes to the fact of inequality in numbers between ganglion cells and neurites, but is unable to express any opinion about its cause.

There exists a general impression that these tumors are benign. Like many other generalizations this is not exact and when it can be shown that 19 or possibly 20 tumors classified as ganglioneuromas have metastasized it will be realized that further elucidation is necessary. As a matter of fact, tumors containing ganglion cells of the sympathetic type are not all fully differentiated growths. Scherer found in otherwise fully differentiated ganglioneuromas what he calls widely separated "development centers" consisting of balls of small darkly stained rounded cells with a perivascular arrangement which he regards as undifferentiated neuroblasts; some may have immature ganglion cells and neuroblasts diffusely scattered among the fully differentiated ganglion cells and a third variety consists of tumors made up compositely of nodules of completely differentiated ganglionic cells and other nodules of completely undifferentiated neuroblasts and perhaps other varieties of neurogenous tumors such as the phaeochromocytomas. Since Scherer's findings have not been confirmed by others and may be lymphocytes (see Case 6) it is probably best to consider his "development centers" as features of otherwise fully differentiated tumors. It is possible then to divide ganglioneuromas into three groups: (1) Fully differentiated, composed entirely of adult ganglion cells with or without satellites set singly or in groups in a bulky matrix composed of enormous numbers of neurites with Schwannian sheaths which occasionally may be myelinated, and an inconspicuous fibrous supporting framework (Figs. 3, 5, 6, 7). (2) Ganglioneuromas with diffusely scattered cells of a less degree of differentiation among the completely differentiated ganglion cells. These show all degrees of variation from sympathicoblasts through sympathicogonia arranged in rosettes and pseudorosettes, on up to almost mature small ganglion cells (Figs. 1, 2, 4, 8, 9). (3) Composite tumors made up of two or more parts, at least one of which will be fully differentiated ganglioneuroma while one or more of the other parts will be neuroblastomatous.

After reviewing available cases from the literature and the 12 cases reported in this paper it was possible to analyze 199 tumors: 146 of them could be considered fully differentiated, 33 belonged to the second group, and 20 to the third. Not one of the first group had metastases. In the second group, 6 metastasized; while 13 of the third group metastasized which is certainly what one would expect, since they are tumors which can be grouped with the neuroblastomas with as much, if not greater propriety than with the ganglioneuromas. Because of the importance of these two last groups, it will be well to record the references. Metastasizing cases are in italics. Group 2 (2, *3a*, 7, 9, 14, *18*, 24, *31*, 33, 34, 36, 37, 42, 44, *65*, 72, 73, 82, *28*, 89, 2 cases, 91, 96, 101, 103, Case 2, 105, 107, 115, Cases 1, 2, 5 and 9, *118a*). Group 3 (*5*, *10*, *14*, Case 2, *15*, *16*, *17*, 23, *28*, 46, 48, 50, *75*, *76*, 78, 83, 103, Case 1, 121, 122, 124, Case 4, Case 9.

This evidence seems to show quite conclusively that the fully differentiated ganglioneuromas do not metastasize. The smaller group with scattered partly differentiated neuro-

blasts is potentially and sometimes actually malignant, since 6 or 18.2 per cent of 33 cases metastasized. The third group with nodules of neuroblastoma distinct from the nodules of ganglioneuroma are fully malignant with metastases in 13 or 65 per cent of 20 cases. A somewhat similar division of the tumors into groups was suggested by Goodhart in 1918, Fischer in 1922, and by Scott *et al.* in 1933, but without an exact tabulation of the degree of malignancy of the different forms.

It would seem from this study that it is probably always desirable to excise ganglioneuromas completely, especially if they belong to the second and third groups. If, however, the tumor belongs to the first group and it is found impossible to remove all of it because of its anatomical relationships, it would seem justifiable to remove as much of the tumor as possible rather than to make no attempt to excise it. It is doubtful if this would accelerate its growth and it might prevent extension through an intervertebral foramen which is an extremely serious and often fatal complication and would obviate at least for a time the unpleasant effects of a very large retroperitoneal or mediastinal tumor. If it continued to grow *in situ* subsequent operations of partial removal might keep it in check indefinitely. If the pathologist is familiar with these types it should be easy to recognize them in a quick frozen section. But what is most urgently needed is more information as to the ultimate fate of many more treated and untreated cases so that the surgeon may be guided in his attack by knowledge rather than hypothesis.

SUMMARY

A brief study has been made of 233 previously published cases of ganglioneuroma of the sympathetic nervous system and 10 new ones. This shows that the common site of these tumors is along the route of the great chain of ganglia extending from the base of the skull into the pelvis including the suprarenal medulla but with a few examples arising from ganglia in other situations. It is possible to divide the cases into three groups: (1) a fully differentiated one which does not metastasize and which includes a great majority of the tumors; (2) a partly differentiated one which occasionally gives rise to metastasis; and (3) a third small but complex group made up both of fully differentiated ganglioneuroma nodules and fully malignant sympathicoblastomatous nodules, the great majority of which metastasize. The histological and biological features of these three varieties is displayed so far as the lamentable lack of follow-up information permits.

CASE 1. E. R., white American girl, 2½ years of age. At 5 weeks of age a mass appeared on the right side of the neck. It gradually increased in size. Examination showed a soft mass extending from the jaw to the lower third of the neck. At operation March 6, 1917, a large mass was removed which extended from the thyroid cartilage to behind the sternomastoid where it reached the vertebrae. The internal jugular was posterior and the common carotid was external to it. Following operation she developed a Horner's syndrome which persisted several years but finally disappeared and on March 12, 1924, 7 years after operation, there was no recurrence. Gross examination showed a 7 by 4 by 3.5 centimeter nodular encapsulated mass. Microscopic examination revealed that the tumor was made up of rather large collections of cells which showed many stages of differentiation from sympathicoblast to fully developed adult ganglion cell. The latter were in the minority. These cells were set in a matrix of delicate fibers which were acidophilic and resemble glia. It was impossible to know how many neurites were present. These collections were enclosed within a dense fibrous stroma in which there were certainly some Schwannian structures but the preparations were not good enough to say how many. No mitoses were recognized (Figs. 1 and 2). Diagnosis was diffuse, partly differentiated ganglioneuroma of the cervical sympathetic ganglion (Stout, 1924).

CASE 2. M. B., white American boy, 2½ years old. When 7 months of age he began to have abdominal pains. Four months before admission he began to develop cord pressure symptoms and finally was unable to sit up and had lost all sphincteric control. X-ray examination showed a dense shadow in the upper left thorax. A needle biopsy showed a ganglioneuroma. Because of the paraplegia, the case was considered inoperable. Seven months later the child was operated upon at the Neurological Institute in an attempt to relieve the cord pressure symptoms which had become progressively worse. A very long encapsulated extradural tumor was found in the spinal canal extending from the upper dorsal into the lower cervical region and continuous with the chest mass through an intervertebral foramen. The child died shortly after the termination of the operation. At microscopic examination, sections of the needle biopsy (illustrated in the published papers) showed groups of differentiated ganglion cells which

Fig. 1. Case. 1. Partly differentiated ganglioneuroma of cervical sympathetic. Topographical photomicrograph showing relative proportion of cells to stroma. ×20.

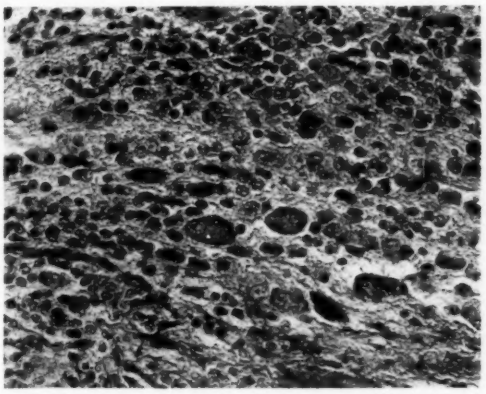

Fig. 2. Case. 1. Detail which shows undifferentiated sympathicoblasts and partly differentiated ganglion cells. ×205.

varied in size from large cells with three nuclei to forms much smaller than normal. They did not have satellites and were set in a loose textured stroma with very few Schwannian structures. The tissue from the spinal canal showed small groups of similar cells scattered at wide intervals in a very thick dense fibrous stroma in which there were apparently many nonmedullated nerves. No special stains were available to confirm this. Diagnosis was fully differentiated ganglioneuroma of upper mediastinum with extension to spinal canal (114, 115).

Case 3. T. F., white American male, aged 25 years, came to the hospital because he was rejected for employment on account of a left indirect inguinal hernia. At operation for cure of this July 28, 1927 a soft spongy mass was found loosely attached to the right spermatic cord just above the testis but separated from it. This was excised and the hernia repaired. Eleven years later there was no recurrence of the tumor. Gross examination showed a firm bilobed tumor measuring 4.5 by 3.5 by 2.5 centimeters encapsulated, pallid and resembling fibrous tissue when sectioned. Microscopic examination showed that nonmedullated nerve fibers furnished with Schwannian and endoneurial sheaths coursed in various directions held together by loose textured connective tissue. Scattered at wide intervals were isolated fully differentiated sympathetic ganglion cells with satellites, pigment and occasionally two nuclei. Diagnosis was fully differentiated ganglioneuroma of spermatic cord.

Case 4. A.M., a Spanish girl, 9 years old, 2 years before admission had an attack of vomiting and fever. She was admitted to another hospital where a retroperitoneal orange-sized tumor was felt. Since then there had been no symptoms. On examination a firm, not freely movable, abdominal mass was felt just to the left of the vertebral column in the lumbar region. X-ray films showed no relation to kidney but left ureter was deviated laterally. Exploration by Dr. William G. Heeks done March 30, 1942 revealed a tumor 12 by 10 centimeters firmly attached to the posterior abdominal wall along the left lumbar vertebrae. Biopsy only was done. Twenty-five months later the mass was still palpable and had not apparently increased in size. Microscopic examination showed this tumor to be made up of widely scattered adult fully differentiated sympathetic ganglion cells with satellites, pigment and neurites set in a fibrous stroma containing vast numbers of nonmedullated neurites sheathed by

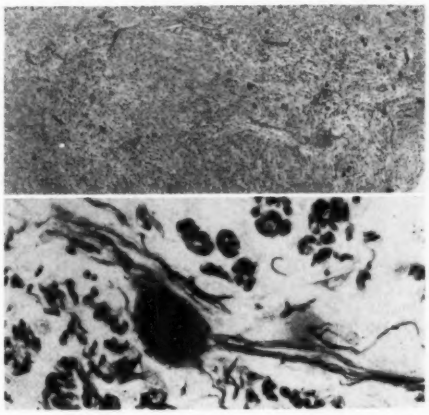

Fig. 3. Case. 4. Differentiated ganglioneuroma of lumbar retroperitoneal region. Above, Topographical photomicrograph showing distribution of ganglion cells in the neurofibromatous stroma. ×20. Below, Detail showing an adult bipolar ganglion cell and neurites. Cajal impregnation. ×205.

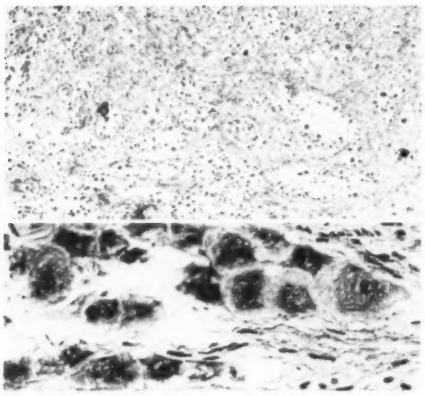

Fig. 4. Case 5. Partly differentiated ganglioneuroma of suprarenal medulla. Above, Topographical photomicrograph. ×20. Below, Detail showing mature and almost mature ganglion cells. Elsewhere there were sympathicoblasts in small numbers. ×205.

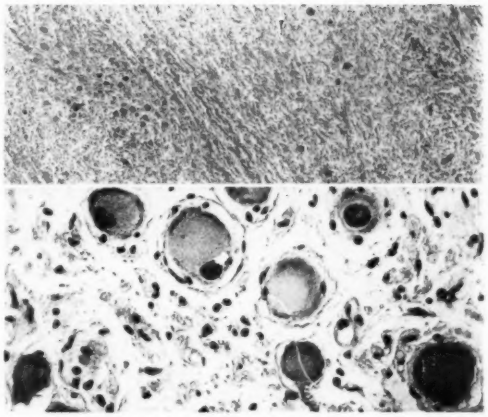

Fig. 5. Case 6. Differentiated ganglioneuroma of pelvic retroperitoneal region. Above, Topographical photomicrograph showing distribution of ganglion cells in the neurofibromatous stroma. ×20. Below, Detail of ganglion cells, satellites and Schwannian sheaths. ×205.

Schwannian cells and endoneurium (Fig. 3). Diagnosis was fully differentiated ganglioneuroma of lumbar retroperitoneal region.

CASE 5. S.F., a 4 year old Cuban female, had abdominal enlargement of 10 months' duration. On examination a mass was felt which displaced the right kidney downward and the intestines to the left. The kidney function was not impaired. X-ray examination showed areas of calcification in the tumor. At operation May 11, 1942, a large solid tumor was found lying superior to the right kidney and pushing it caudad. It was encapsulated, not adherent to kidney or liver. The mass was retroperitoneal and its blood supply came from the adrenal vessels. It was easily excised by Dr. George Cahill. The child made a good recovery and 22 months later showed no evidence of recurrence. Gross examination by Dr. Dorothy H. Andersen showed an encapsulated mass measuring 9.5 by 8.5 by 7.2 centimeters and weighing 320 grams. It seemed to be made up of one large and several smaller flattened nodules. When cut open the knife grated against several areas of calcification. Microscopic examination revealed that this tumor was made up of numerous rather large groups of ganglion cells many of which were fully differentiated while some were only partly differentiated and occasionally sympathicoblasts were present. In the surrounding stroma are many Schwannian and endoneurial structures which probably enclose neurites. The whole tumor has suffered from degeneration with patches of calcification so that accurate histological study is difficult (Fig. 4). Diagnosis was diffuse partly differentiated ganglioneuroma of right suprarenal gland.

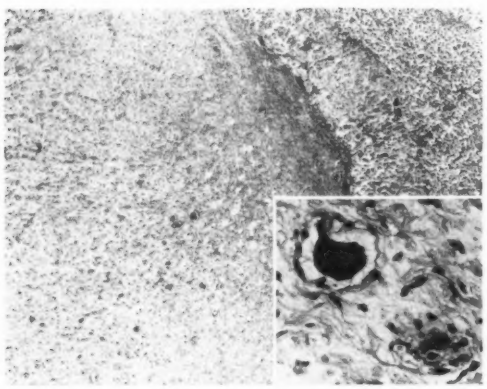

Fig. 6. Case 7. Differentiated ganglioneuroma of suprarenal medulla showing tumor at the left and suprarenal cortex at the right. ×20. Inset shows two partly degenerate ganglion cells and satellites. ×205.

CASE 6. J. LaP., white married American female of Slovak extraction, 18 years old, was a primipara who was found to have a mass in the hollow of the sacrum indenting the rectum during routine antepartum examination. This necessitated delivery of the baby at term April 10, 1943 by cesarian section. The tumor was entirely retroperitoneal extending from the promontory of the sacrum to its fourth segment slightly to the left of the midline. It was firm rubbery, and irregular in consistency. It was 8 centimeters long and varied from 3 to 5 centimeters in width. It had a very firm attachment to the sacrum and because of this removal was not attempted. The capsule was from 2 to 3 millimeters thick. Two biopsies were taken. The child was a normal baby girl. The patient recovered and was alive April 25

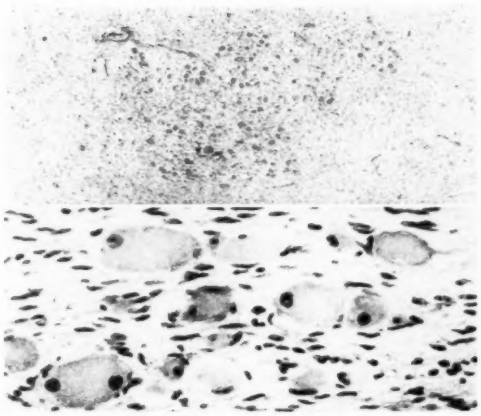

Fig. 7. Case 8. Differentiated ganglioneuroma of pelvic inlet. Topographical photomicrograph above, ×20, and detail of cells below, ×205.

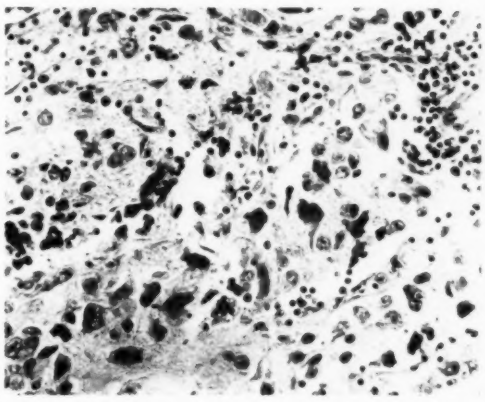

Fig. 8. Case 9. Partly differentiated ganglioneuroma of cervical sympathetic ganglion metastatic in cervical lymph node. Detail showing undifferentiated sympathicoblasts and almost fully differentiated ganglion cells. ×205.

1946, nearly 3 years later with the tumor apparently stationary. Microscopic examination revealed that the tumor was enclosed by a thick fibrous capsule with a small area of calcification. It is made up of numerous endoneurial and Schwannian sheaths without myelin which course in various directions at haphazard loosely held together by a delicate fibrous stroma. Scattered at rather infrequent intervals are groups of fully differentiated pigmented sympathetic ganglion cells attended by satellites. Some of them have two nuclei and many are without nuclei. The majority are normal in size but occasionally small forms are encountered. All appear fully differentiated. In one section some small rounded cells are collected about a capillary. These appear to be lymphocytes, monocytes, and plasma cells rather than an example of Scherer's "development centers" (Fig. 5). Diagnosis was fully differentiated ganglioneuroma of pelvic retroperitoneal region.

CASE 7. S.P., 22081, G. L., aged 71 years, died with a cancer of the larynx and autopsy was performed at the Pilgrim State Hospital, West Brentwood, L.I., by Dr. Edward W. Gray. The right adrenal was enlarged to dimensions of 14 by 10 by 7 millimeters by the presence of an encapsulated medullary tumor 1 centimeter in diameter. Microscopic examination showed a tumor made up of countless interlaced nonmedullated nerve fibers enclosed within Schwannian sheaths. Scattered among these at intervals are fully differentiated ganglion cells in various stages of degeneration and generally enclosed by satellite cells (Fig. 6). Diagnosis was fully differentiated ganglioneuroma of suprarenal medulla.

CASE 8. Female, aged 14 years, began to menstruate 1 year before admission to Fordham Hospital. For an unstated period she had suffered from intermittent attacks of abdominal pain and a mass in the left lower quadrant which had not changed in size. Examination showed an egg-sized, hard, smooth mass in the left lower quadrant a little below the umbilicus. Intravenous pyelogram showed that the left ureter was displaced outward by a retroperitoneal mass. At operation the mass lay between the left ureter and the left common iliac artery. It was excised without difficulty. The patient made a good recovery but was not followed after she left the hospital. The specimen was examined by Dr. Nathan Block. It was an irregularly globoid, solid, encapsulated mass 6 centimeters in diameter which on section showed a homogeneous, moist, light brown surface streaked with grayish-yellow fine bands. Microscopic examination showed the tumor to be made up of groups of ganglion cells most of which

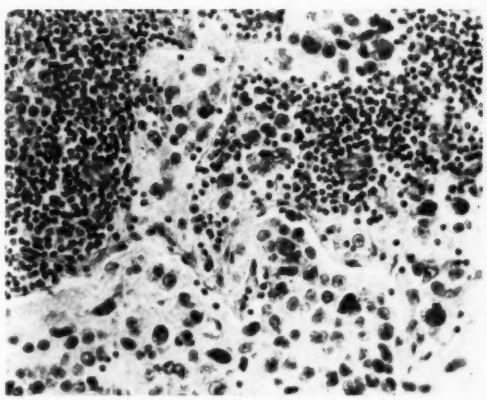

Fig. 9. Case 9. Tumor cells in lymph sinuses. ×205.

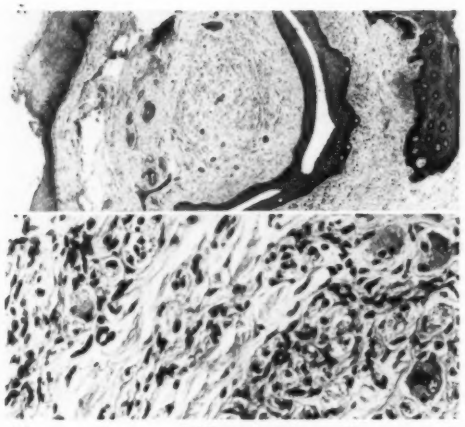

Fig. 10. Case 11. Differentiated ganglioneuroma (or hyperplastic ganglion) of the tongue. Above, A tangential section showing part of the lesion beneath the mucosa. ×20. Below, Detail showing ganglion cells and nerve sheaths. ×205.

were fully differentiated, pigmented, and often furnished with satellites. Large forms with two or even three nuclei could be found and also small cells which are otherwise fully differentiated. Some cells had vacuoles and appeared to be disintegrating. The ganglion cells were scattered throughout a stroma made up of numerous endoneurial and Schwannian sheaths in a fibrous framework varying from loose textured to dense. No myelinated nerves were recognized (Fig. 7). Diagnosis was fully differentiated ganglioneuroma of lumbosacral retroperitoneal region.

Case 9. G.H., white male, 20 months of age, at 7 months of age had had a severe cold and the cervical nodes enlarged especially on the left side. During the succeeding months there were a number of similar attacks with fever. Finally tremor of the head and neck developed with weakness and obstructive breathing. Examination showed numerous enlarged nodules on the left side of the neck. X-ray films of chest were negative. Finally a biopsy of one of the nodules was done. Following this the nodules in the neck continued to increase reaching the size of two fists at 19 months after biopsy. (Information and material furnished by Dr. J. H. Ferguson, Syracuse University, N.Y.). Microscopic examination showed the sections to include portions of what appeared to be a lymph node which had been partially replaced by a tumor which tended to spread along the sinuses. This was made up of what appeared to be sympathicoblasts in various stages of differentiation. They never attained the status of fully differentiated ganglion cells but approached it occasionally when unipolar cells were formed. There were no satellite cells and the tumor cells were set in a matrix resembling glia. No special stains were available so that it was unknown how many neurites were present. It was assumed that there were some because some of the cells had polar prolongations. No mitoses were found nor were there any rosettes or pseudorosettes (Figs. 8 and 9). Diagnosis was diffuse partly differentiated ganglioneuroma of cervical lymph node metastatic from the cervical sympathetic ganglion.

Case 10. 24054, E. W., white married female, aged 26 years, for 11 months had suffered from increasingly severe pain in left side with extension down the legs on standing but relieved by lying down with legs pulled up. She had given birth to two children and had had no miscarriages. Examination revealed a fixed nodular mass in the left adnexa 2 inches in diameter. At operation August 9, 1945 a solidly fixed tumor overlay the left common iliac vessels behind the peritoneum. It was deemed

Fig. 11. Case 12. Photograph of area involved by neurofibroma. The dark pigmented areas are pigmented moles.

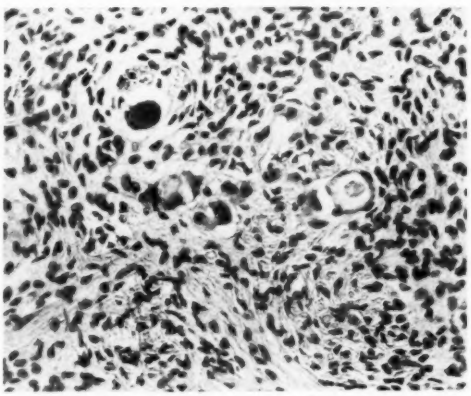

Fig. 12. Case 12. Detail from a neurofibromatous area in the corium showing differentiated ganglion cells among the proliferated Schwannian cells.

inoperable and only a biopsy was taken. There was marked bleeding during the operation and the patient went into shock. She was given 3 plasma and 1 blood transfusion but died 9 hours after termination of the operation. It was not decided whether death was from shock or pulmonary embolism. There was no autopsy. (The clinical history was furnished by Dr. Leona Kasten and the pathological material by Dr. Alvin O. Severance of San Antonio, Texas.) Microscopic examination showed the tumor to be composed of great numbers of Schwannian and endoneurial sheaths growing in various directions embedded in dense fibroblastic tissue. Set in this at wide intervals were small groups or isolated units of adult sympathetic ganglion cells furnished with satellites. A few cells had two nuclei and many showed vacuolization and other signs of degeneration. A vast majority of the sheaths were nonmyelinated but at least two myelinated ones were recognized. Diagnosis was fully differentiated ganglioneuroma of pelvic retroperitoneal region.

CASE 11. Age and sex of patient were not stated. A swelling was noted for several months in the region of the circumvallate papillae. It was assumed that the swelling was an enlarged circumvallate papilla. A slide of the lesion was contributed by Miss Leila M. Hawksley, pathologist of the Royal Cancer Hospital (Free) of London, England. Microscopic examination revealed that the swelling had been produced by the presence in the submucosa of a mass composed of numerous small nerve bundles with both myelinated and nonmyelinated neurites, held together by a generous but loose textured fibrous stroma. Scattered at infrequent intervals there were isolated sympathetic ganglion cells with satellites and pigment. They appeared fully differentiated. The involved area extended diffusely and was not encapsulated. In places it had included ducts of the local serous and mucous glands. It had the appearance of a much enlarged normal sympathetic ganglion (Fig. 10). Diagnosis was ganglioneuroma of tongue.

CASE 12. C. F., a Puerto Rican girl, 21 months old, ever since birth had had a raised pigmented hairy lesion which occupied the bridge of the nose, the right infraorbital region and lower eyelid and the right zygomatic area as far as the hair line. It was soft, nodular, elevated a centimeter in some places, showed many pigment dots, and had many fine silky hairs growing out of it. A large portion of it measuring 11 by 4 centimeters was excised by Dr. J. P. Webster January 3, 1930. Following this the tumor reappeared in the cicatrix and continued to grow. A second attempt to excise the recurrence was made July 25, 1930 but the child died during the operation (Fig. 11). Microscopic examination showed that in this highly complex tumor the skin was thickened by a growth composed of plexiform neurofibromatous nerves which as they approached the epidermis occasionally formed terminal neuromas containing adult sympathetic ganglion cells with satellites. In places the Schwannian cells had proliferated around the nerves to form sheaths of atypical and quasi malignant aspect. Just beneath the epidermis were groups of pigmented mole cells. In places these were in direct continuity with the proliferated Schwannian cells (Fig. 12). This condition was evidently a manifestation of von Recklinghausen's disease in which the plexiform neurofibromas had formed multiple small ganglioneuromas in the skin. Diagnosis was ganglioneuromas of skin of face forming parts of the plexiform neurofibromas of von Recklinghausen's disease.

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PLANTAR NEUROMAS, MORTON'S TOE

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IN 1876 Morton described, and cited examples of, a peculiar and painful affection of the fourth metatarsophalangeal articulation. His observations and descriptions need little amplification except to emphasize that here is a condition in which the exact pathologic process is now known and the cure is in the hands of physicians. Morton succeeded in obtaining cures in this condition by excision of the metatarsophalangeal joint and surrounding soft tissues, including "the nerves distributed about the joint." Diseased tissues, however, were not identified by him.

There ensued a number of articles confirming Morton's observations (3, 4, 10) and making the condition a clear-cut clinical entity, which has received his name. In an interesting lecture in 1887 on "Pain in the Feet," giving full credit to Morton and adding a few cases of his own, Mills expressed the belief that the trouble was limited to the branches of the external plantar nerve going to the fourth and fifth toes. He suggested that this nerve might be resected or stretched.

In 1893 Hoadley reported data on 6 cases of metatarsalgia. In one of his cases (II), in which the condition failed to respond to conservative treatment, he performed operation. His findings were significant. Unfortunately for patients suffering from this condition these findings were not generally known for nearly 5 decades. In the case in question Hoadley exposed the digital branches of the lateral plantar nerve to the fourth toe and found a small neuroma. He then resected the nerve. "A prompt and perfect cure" was obtained. He expressed the opinion that if operation was advisable excision of the nerve was simpler and recovery prompter than excision of the metatarsophalangeal joint as advised by Morton.

Robert Jones and Tubby in a lengthy article in 1898 reviewed past literature and discussed the subject thoroughly. Pathologically, they observed a "well-marked state of neuritis of the digital nerves" in 2 of their cases in which operation was performed. Apparently, they missed the significance of Hoadley's observations, although they referred to him in the bibliography. They held to the operation of resection of the metatarsophalangeal joint though they noted that the nerve could be destroyed by cautery, by injections of phenol, or lastly, by resection of the digital plantar nerve. They objected to the plantar approach to the nerve.

Not until 1940 was the thread of constructive surgical treatment and exact pathologic basis picked up by Betts, of Australia, who reported the true situation in a concise and valuable article. Unequivocally he attributed true Morton's metatarsalgia to a plantar neuroma, excision of which through a plantar incision produces a prompt cure.

In this country McElvenny separately came to the same conclusion as Betts and published his work in 1943. He expressed preference for a web splitting incision because of the early ambulation which this method affords. He observed that the tumor is rather on the lateral branch of the median plantar nerve, which innervates the third and fourth digits.

The most recent confirming article is that of Baker and Kuhn, who reported 14 operations with removal of plantar neuromas, cures being obtained.

We hope that this work may stimulate others to consider operative treatment in the care of intractable pain due to Morton's toe. We, also, should like to add a bit more on the histopathology of this condition.

CLINICAL ASPECTS

Typically the symptom complex known as Morton's toe is rather stereotyped and has been described many times. The patients have severe paroxysms of pain, which usually arise beneath the heads of the third and fourth metatarsals and extend into the opposing

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Fig. 1. Fusiform enlargements of fourth digital nerves typifying the average lesion found in "Morton's metatarsalgia." Bilateral involvement.

sides of the third and fourth digits. Of the cases reviewed 1 patient had bilateral pain into the second and third digits, and in 4 feet pain extended into the fourth and fifth digits. The pain may extend up the posterior aspect of the leg as far as the hip. Most commonly the attacks come on while the victim is walking. However, 5 patients studied described paroxysms of pain which came on while in bed, some being awakened from sound sleep as a result.

Paresthesias into the affected toes were experienced by 15 of the 18 patients studied. Cramping of the foot and toes was fairly common. Four patients stated that their trouble was much more frequent during warm weather than at other times and was relieved somewhat by cold applications. Vasomotor changes in the form of cyanosis of these toes have been noted in 1 case.

In this series there were 16 women and 2 men, whose ages ranged from 25 years to 67 years. The majority of these patients tended to be somewhat overweight. Symptoms had been present from 3 months to 12 years, occurring in the right foot in 12 cases and in the left foot in 12 cases. In 5 of the cases the symptoms were bilateral, and in 1 case 3 neuromas were removed. Symptoms were classified as atypical in 3 cases and questionably typical in 2 other cases.

Physical findings. In 16 of the 18 patients studied there was a well localized tender spot over the site of the neuroma. In contrast to reports in the literature, when firm deep pressure with a rounded blunt instrument was exerted over the site of the neuroma, the radiating pain and the paresthesias into the affected toes were reproduced in the majority of patients. Compression of the ball of the foot and rough manipulation of the third and fourth metatarsals in some cases caused similar symptoms. Occasionally, subjective numbness in the third and fourth toes was noted on light touch.

Treatment. Conservative treatment should always be given a preliminary trial. The irritation of this nerve or neuroma may be stopped by shoes of sufficient length and width. External transverse bars or suitable padding within the shoe may relieve the symptoms. Persistent symptoms are best treated surgically.

In all but 1 of this series a plantar incision between the heads of the metatarsals was used. It is felt that since the nerves lie just beneath the plantar fascia and below the deep transverse metatarsal ligament, better exposure and a wider resection can be carried out through this incision. The proximal end of the nerve can be severed well back into the short muscles of the foot and future irritation of the inevitable amputation neuroma is avoided. The neuroma does not always lie distal enough to allow visualization through a dorsal or web splitting incision without severing the deep transverse metatarsal ligament. There occasionally is an anomalous nerve, lying on the upper surface of this ligament, but none have been encountered in this series. Several neuromas have been removed which were proximal to the heads of the metatarsals; in these cases an approach through the web would have been difficult.

These neuromas may occur in 3 different sites along the plantar nerves. They may be distal to the bifurcation in the digital branches. They may be at the bifurcation of the nerve

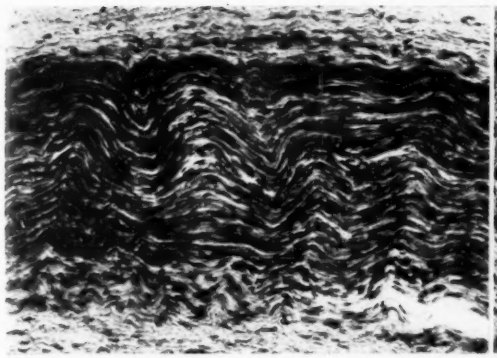
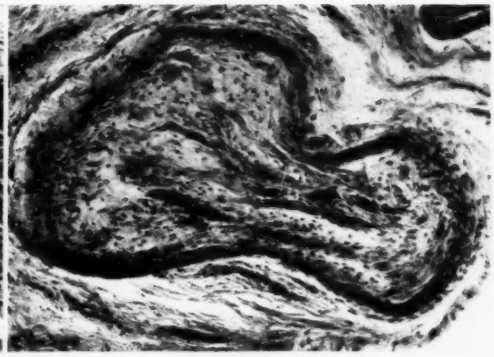


Fig. 2.



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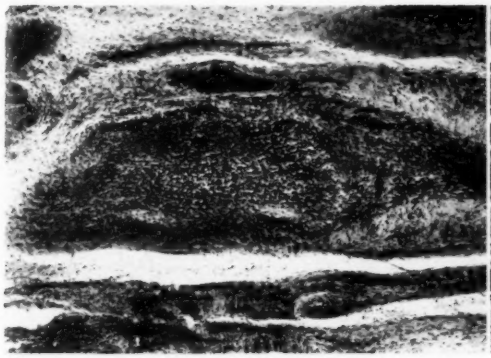

Fig. 4.

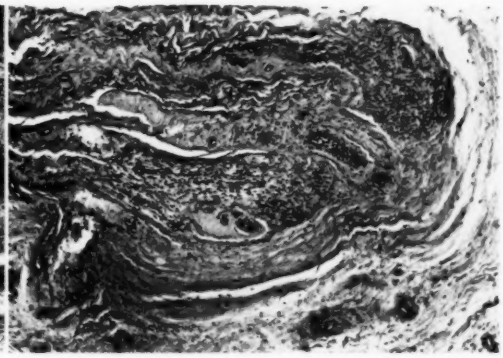

Fig. 5.

Fig. 2. A normal fourth digital nerve showing wavy myelinated nerve fibrils with neurilemma nuclei (hematoxylin and eosin ×145).

Fig. 3. Morton's metatarsalgia, early lesion showing swelling of the nerve trunk from neural and perineural edema. Only a few fibrils appear to be well myelinated (hematoxylin and eosin ×75).

Fig. 4. Morton's metatarsalgia. The outstanding features of this neuroma are seen to be neural edema and a marked proliferation of neurilemma nuclei. Perineural tissue shows edema and beginning fibrosis. One well formed vessel is seen (hematoxylin and eosin ×40).

Fig. 5. Fourth digital "neuroma" showing some perineural edema with marked fibrosis and hyalinization. Islands of hyaline tissue are seen invading the nerve substance, which also shows residual proliferation of neurilemma nuclei. The lesion is a moderately late one (hematoxylin and eosin ×50).

into its digital branches, or the neuroma may be in the median branch of the plantar nerve before its bifurcation.

Healing of this incision has been prompt and complaints of minor tenderness in the scar were voiced by only 2 patients. The advantage of early weight bearing and ambulation, when a dorsal or web splitting incision is made, is important. It may be that with further use this approach will prove the better.

The operation is done with a tourniquet around the lower part of the leg, a large Penrose drain being wrapped about the leg at the musculotendinous junction of the gastrocnemius muscle. After the neuroma is removed, the incision is accurately and carefully closed with interrupted sutures of No. 0000 zytor. Weight bearing on the ball of the foot is allowed in 2 weeks.

Results. We cannot report perfect results in all 18 of the cases herein reported. We may have been somewhat overenthusiastic in our endeavors to relieve chronic distress in the feet. However, in all of the cases recorded neuromas were proved histologically. In 1 case exploration was performed and the pa-

Fig. 6. Fourth digital "neuroma" approaching the end stage with the nerve difficult to identify in a mass of relatively cellular collagenous and hyaline fibrous tissue (hematoxylin and eosin ×7.8).

tient was relieved of distress although the sections were not conclusive of a neuroma. This patient was not included. Thirteen of the 18 patients were very pleased with the result, having complete relief of pain. Two patients had some but not complete relief. One patient was operated on whose history would make one suspect that she had painful osteoporosis of the foot, secondary to a plantar neuroma. A neuroma was found and removed, but at the time of writing the result is unsatisfactory.

Two patients have been operated on too recently to evaluate the result.

The gratitude of patients who have benefited is ample proof of the value of this rather minor operation.

PATHOLOGIC ASPECTS

Grossly, the neuromas presented either as pancake-like thickenings or as fusiform swellings of the involved nerve trunks. These thickenings tapered away proximally and distally into the adjacent and grossly normal nerve segments. The average size was small, with a length of about 15 millimeters and the diameter half that of an ordinary lead pencil (Fig. 1). The bulkiest of the tumors was 2.5 centimeters in length and 1 centimeter in diameter while some of the smaller lesions brought the size of the involved nerve to a thickness only twice or three times that of the normal nerve.

All of the tumors were pearly white and all were encapsulated. The consistency was firm but in some of the early lesions the tissue appeared to be edematous. Cut sections failed to reveal any regions of cyst formation, which had been noted by McElvenny in his series.

The location of these tumors has been described earlier in this paper.

Microscopically, certain pathologic processes involved (1) the nerve trunks and (2) the surrounding connective tissue sheath (Figs. 2 to 6, inclusive). Early and late lesions were found in both locations. The commonest and the earliest nerve change consisted in interstitial edema, spotty in character, associated with irregular demyelinization and swelling of the entire nerve trunk. Accompanying or shortly following this there appeared to be a rather marked proliferation of the neurilemma nuclei, giving a picture of pronounced cellularity. In some, the proliferation was central and in others predominantly peripheral, but in general the proliferation was quite diffuse. Like the edema, the proliferative process was often spotty or focal in distribution. A combination of edema and proliferation in 4 instances gave rise to the formation of tissue clefts or small cysts within the substance of the nerve. In long standing lesions moderate to severe degrees of fibrosis and even hyalinization were seen to affect the thickened nerve bundles, but this process seemed to represent an invasion from without rather than a primary nerve change. Three of the lesions were classified as being early, 10 late, and the remainder showed changes of an intermediate grade. One could not always estimate the duration of symptoms from a microscopic examination of the neuromas.

As noted by McElvenny and by Baker and Kuhn the "neuromas" consisted for the most part of collagenous tissue encasing the abnormal nerve lesions described previously. Again, what might be termed early and late changes were observed. In the early changes, perineural edema, usually marked in degree, was almost always associated with proliferation of connective tissue fibroblasts. The edema often produced a "spidering" of these fibroblasts, the nuclei of which appeared degenerated and vacuolated with loss of nucle-

olar substance. Pseudocyst formation was noted in 5 cases in which high grades of edema were present. Edematous collagen, seen in the early stages, was replaced by the hyaline substance of long-standing lesions, the end-result being a perineural scar which as noted previously tended to invade the substance of the incased nerve, the fibers of which often became widely separated as a result.

All of the lesions appeared fairly vascular microscopically. In older ones the vessels appeared thick walled and sclerotic, with endarteritis and occasionally thrombosis. In the early stages, edema was often present in the walls of the vessels, suggesting the effect of trauma rather than that of any special lesion like thromboangiitis obliterans.

Pathogenesis. Practically all of the patients who have Morton's toe are women. Almost all of them had been in the habit of wearing small, high-heeled shoes and had resorted to the more homely but hygienic slipper for relief of their foot trouble. Two of our patients were men; one wore narrow shoes because his feet were too wide. The other dated his trouble to a period when he was working in a war plant and was forced, by plant regulation, to wear ill-fitting, steel-capped boots. These and other features point to trauma and weight bearing as the prime causes of the affliction. Traumatic edema of the nerves causes swelling and demyelinization, which further expose the nerves to trauma and complete a vicious circle. Proliferation of the nerve fibers and of the perineural fibrous tissue is but a natural consequence of this edema and local irritation. Although complete scarring is the theoretical end-result, enough nerve fibers escape so that in none of our cases did the pain disappear with the passage of time. But why should the fourth digital nerve be selected for the development of the neuroma? Betts set about to discover the reason and developed his hypothesis on an anatomic basis. His findings were confirmed by McElvenny and by Baker and Kuhn; we have personally substantiated them in a number of dissections. The principle is demonstrated in Figure 7.

The fourth digital nerve, unlike its neighbors, is of double derivation, being formed through the anastomosis of branches from

Fig. 7. Diagram made from an actual dissection showing the dual derivation of the fourth digital plantar nerve. Note the transverse sling across the belly of the flexor brevis muscle. Anchoring of the nerve resulting from this anatomic relation is supposed to lead to trauma of the nerve.

both medial and lateral plantar nerves. It is consequently somewhat thicker than its mates —a fact which in itself might indicate increased vulnerability to trauma. But more importantly, the arc described by its two constituent branches forms a transverse sling across the outer or superficial aspect of the flexor brevis digitorum muscle. Whereas the other digital nerves, lying as they do in deep grooves between the muscles of the foot, enjoy a certain degree of mobility in a longitudinal direction, the fourth nerve is more or less anchored posteriorly. Stretching of the aforementioned loop occurs during dorsiflexion of the foot and toes, and in walking the degree of stretch is intensified by contraction of the enclosed flexor belly.

Finally in all fairness to the "opposition" it must be admitted that the offending loop is sometimes absent in these cases and that

tumors of comparable nature affect the other branches of the plantar nerves. Baker and Kuhn expressed the belief that in some of these cases nerve irritation was brought about by anomalous positions of the nerves in relation to the transverse metatarsal ligament.

SUMMARY

The affliction formerly called Morton's toe or Morton's metatarsalgia has its pathologic basis in a tumefactive perineural fibrosis of the fourth digital nerve of the foot. Degenerative as well as proliferative nerve changes along with neural and perineural edema are additionally present. The lesion may affect digital nerves other than the fourth, the predilection for which may be determined by anatomic peculiarities in composition. There is considerable evidence that trauma from weight bearing in small or otherwise ill-fitting shoes is responsible for the pathogenesis of the lesion. In intractable cases the most promising treatment is resection of the affected nerve.

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ANTERIOR TRANSPLANTATION OF THE POSTERIOR DELTOID FOR SHOULDER PALSY AND DISLOCATION IN POLIOMYELITIS

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TRANSPLANTATION of muscles at their superior attachment, or origin, for any purpose has not been widely practiced or attempted. Since the orthopedic surgeon performs muscle and tendon shifts most frequently in patients with residual paralysis from poliomyelitis, it would be expected that the need for shifting the origin of muscles would be encountered for the most part in this group of patients. Ober has described three operative procedures that may be utilized to restore some of the abduction power lost at the shoulder by paralysis of the deltoid. By one method, the origin of all, or a portion, of the pectoralis major is transferred to the spine of the scapula. In another technique, the short head of the biceps and the long head of the triceps are transferred to the region of the acromion process. This author also recently described the same method employed in this case, but he did not use it for the cure of paralytic dislocation at the shoulder. Steindler's shift of the forearm flexors is well known.

Lange transplanted the origin of the vastus lateralis to the external surface of the ilium in lateral hip muscle palsy. Legg shifted the origin of the tensor fasciae femoris backward to the iliac crest to improve abduction at the hip. The results from these two latter procedures have not been spectacular, possibly because of overwhelming paralysis in other hip muscles. It has been recognized, though, that such origin transplants contract actively after the operation. Silfverskoild described a technique for transplanting the origins of the long head of the biceps and the semimembranosus and the semitendinosus downward into the posterior femur for flexion contracture of the knee. Girard described an operation transplanting the origin of the hamstring muscles to the symphysis pubis to increase adduction power.

Although it is well recognized that portions of the deltoid may atrophy from the effects of poliomyelitis, there is no description of the end-results of cases in the literature in which the origin of the remainder of the functioning deltoid has been transplanted to improve the abduction power of the arm. In the case the outcome of which after 4 years is recorded in this report, the origin of the remaining functioning posterior third of the deltoid was transferred from the scapular spine to an anterior site corresponding to the normal origin of the anterior deltoid (see Figs. 2 and 3). This transplant effected a cure of dislocation of the upper humerus which occurred habitually when the patient contracted the remaining posterior third of the deltoid in attempting abduction prior to the transplantation. The posterior third unopposed by the middle and anterior third pushed the humeral head anteriorly as it contracted along a line posterior to this structure (see Fig. 2). It was obvious that an anterior and more direct line of contraction would utilize the function of the remaining fibers more effectively and at the same time would tend to restrain the humeral head. The effectiveness of the posterior deltoid prior to transplantation in this case was further reduced by the mechanical disadvantage produced by dislocation.

REPORT OF CASE

R. M., male, aged 11 years was first seen in 1940, 3 years after an acute attack of anterior poliomyelitis. The acute paralysis was said to have involved the "whole arm" on the right side. He had received efficient and continuous after-care and had recovered a fair degree of muscle power in the right arm. His appearance at the time is shown in Figure 1a. There was extensive muscle atrophy around the right

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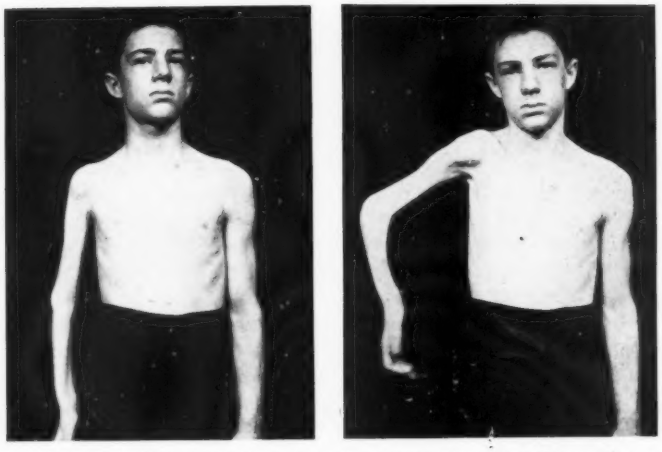

Fig. 1. a, left, Appearance of patient prior to operation. Note the prominence of the humeral head with the arm at rest at the side. b, Maximum abduction possible before operation. The humeral head is dislocated anteriorly.

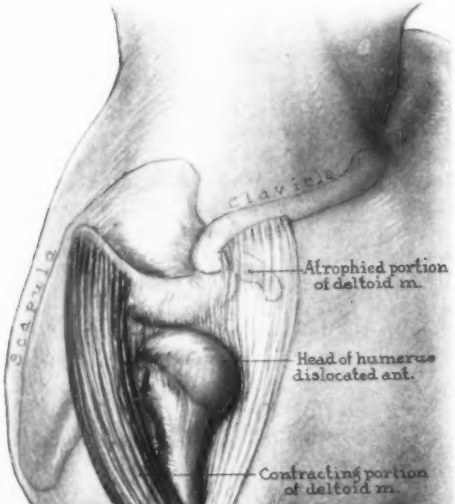

Fig. 2. The drawing illustrates the anatomic situation of the functioning posterior deltoid prior to its transplantation. Note the relation of the humeral head to the muscle.

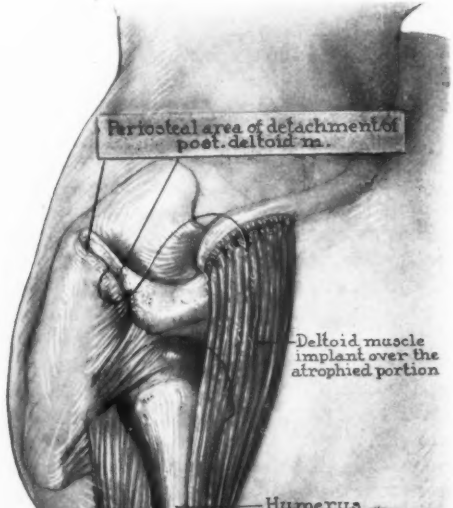

Fig. 3. Anatomy of the transplanted deltoid remnant. When the transplant contracts it retains the humeral head in the glenoid as well as exerting a more direct pull in abduction in neutral and the frontal plane.

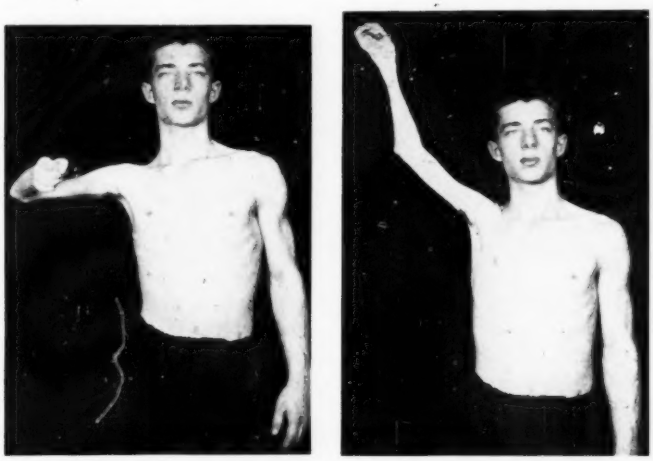

Fig. 4. a, left, Appearance of the patient 4 years after operation when the right arm is held at right angle abduction. b, Hyperabduction as carried out at the same time interval. Note hypertrophy of the deltoid transplant and the increased range of active motion.

shoulder and in the arm and forearm of the same side. The humeral head could be seen and palpated with ease since the anterior and middle portions of the right deltoid were reduced to nonfunctioning ribbons. The posterior deltoid remained functioning, but its mass was less than that of the corresponding portion of the normal left deltoid. The right biceps brachii was functioning, but its strength was inadequate. The wrist was semiflail. The only muscle power remaining in the forearm was the extensively weakened long flexors and extensors of the thumb and fingers. Of the group of wrist extensors and flexors, only the weakened flexor carpi ulnaris remained. The grasping power of the fingers was inadequate due to inability to fix the wrist. Another major mechanical difficulty with the right upper extremity was a pathologic anterior dislocation which occurred whenever the patient attempted to abduct the left arm (see Fig. 1b). Due to the combined effects of muscle weakness and mechanical disadvantage of dislocation, the right upper extremity was useless. The indications were to stabilize the wrist and to improve the function of the upper arm and shoulder.

On December 16, 1940, an arthrodesis of the proximal carpals to the right radial epiphysis was done and a tenodesis of the right upper humerus carried out by burying the scarified upper tendon of the long head of the biceps under osteoperiosteal flaps raised from the bicipital groove. Although protected adequately after the operation, the right shoulder again began to dislocate during the spring of 1941, and within a few more months it was obvious that restraint by the atrophic biceps tendon was not sufficient. The radial-carpal arthrodesis improved the function of the hand to a marked degree.

On April 6, 1942, transplantation of the posterior deltoid origin was performed. An 8 inch curved incision was made extending from the middle third of the clavicle, slightly downward but chiefly backward, to the middle of the scapular spine. Flaps of skin and subcutaneous tissue were raised superior and inferior from the line of incision. The active posterior third of the deltoid was detached subperiosteally from its scapular origin and freed distally on a plane beneath the muscle to about half its length. This maneuver was carried out carefully to avoid injury to the branches of the axillary nerve. In this instance, these branches were unusually long and allowed good mobilization of the deltoid remnant. The outer third of the clavicle was bared by periosteal dissection. The free former origin of the muscle flap was then anchored by many interrupted stitches of cotton to the outer clavicular site. The wound was closed and the arm retained in a frontal plane in 105 degrees abduction by a body and arm plaster spica.

The upper half of the arm portion of the cast was removed after 3 weeks, the stitches removed, and light massage and active motion begun. The whole cast was removed after 5½ weeks and the arm supported upon an aeroplane brace. Active abduction exercises were continued. The patient could easily hold the arm against gravity for a few minutes at 6 weeks, but he continued to wear the brace for protection for 4 months more. The transplanted deltoid continued to improve in function. When last seen in March, 1946, almost 4 years after the transplant, the function of the right shoulder was nearly normal. Abduction could be performed smoothly against considerable added resistance, and the degree of abduction could be maintained against both gravity and added resistance at any height. There were no jerky "throwing" motions such as were present prior to operation. Figures 4, a and b show his appearance at this time as he held the arm at two levels of abduction. By this time the transplanted posterior deltoid had hypertrophied to a muscle mass of at least three times its size prior to operation. There has been no recurrence of dislocation at the right shoulder since operation had been performed.

An additional bone grafting operation to span the distal ulna and carpus to the fifth metacarpal for preventing increasing ulnar deviation of the hand was done a year previous to the last observation. The graft was fixed to the ulna and fifth metacarpal with two vitallium screws at each site. This procedure achieved its purpose.

SUMMARY

A case report is presented demonstrating the result after 4 years of transplanting the origin of the functioning posterior deltoid to an anterior site in poliomyelitic paralysis affecting the middle and anterior portions of this muscle. Habitual dislocation of the shoulder has not recurred since the operation. The transplanted muscle has hypertrophied on use to more than three times its mass prior to operation. The function of the shoulder has been virtually normal during the last 2 years of observation.

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EDITORIAL

SURGERY
Gynecology and Obstetrics

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JANUARY, 1947

PROBLEMS OF NURSES AND DOCTORS

THE primary purpose of this editorial is to provoke thoughtful consideration of the growing schism between the medical and nursing professions. An effort will be made to enumerate and to analyze some of the difficulties that have arisen; one approach to their solution will be suggested.

There is real dissatisfaction on the part of many doctors with the nursing profession, and there is similar dissatisfaction on the part of some nurses with the doctors. This situation is unfortunate. It seems to be growing worse. In fact, one of the leading surgical associations of the country has recently appointed a fact-finding committee to enquire into the degree and character of the surgeons' complaints. In any co-operative endeavor, both partners lose when friction occurs. It is important then to separate our real problems from imaginary ones, and to seek the solution of these real difficulties with determination and good will.

To begin with, it is obvious that there is not just a single point of difference between the doctors and the nurses. The relationship between these two groups varies greatly in different communities. The complaints of the surgeons in Chicago are not identical with those of their confrères in Boston, Dallas, or Hagerstown. There are, however, certain basic dissatisfactions. These are widespread and easily recognized. The first is that doctors everywhere complain about the inadequate number of nurses, and about the high cost of nursing care. Furthermore, most doctors are not in sympathy with the rising educational requirements of the nursing schools. On the other hand, the leaders in nursing (the heads of schools, associations, and licensing boards) are provoked with the doctors for this lack of sympathy. Finally, many nurses, particularly the older ones, are keenly aware of a loss of *esprit de corps* in their group.

There are insufficient nurses to meet the needs of our civilian population. This is due to several factors, such as the increasing demand of the public for nurses, the requirements of the Government services, and the failure of nurses after discharge from the armed services to return to civilian work. The most important factor is the failure of the profession to attract and to hold young women. This failure is primarily an economic one. The period of preparation is out of proportion to the compensation given graduate nurses. An additional factor that applies only to nurses continuing in their field is the ever increasing boredom of their task. The doctor has three great forces to hold his interest in his work; one is the increasing responsibility of a growing practice; a second is the en-

larging financial reward; and a third is the mental stimulus of keeping up with advances in medical knowledge. The average graduate nurse has none of these stimuli to enliven her work. For her the glamor of the uniform soon fades, and she does the same work for the same pay year in and year out. The leaders of the nursing world have not devised any method of making the work of the graduate nurse increasingly interesting or increasingly responsible.

Although many people complain about the cost of nursing care the fact remains that graduate nurses are underpaid. This difficulty arises from an improper distribution of work. No method has been developed for relieving the highly trained graduate of that part of her work that can be done by less skilled workers. During the recent War the Nurses' Aids showed how much can be accomplished in this direction, but are these exceptional women continuing to work in our hospitals? If not, what steps are being taken to replace them? Under the present allocation of work it is impossible to pay nurses adequately, or to provide nursing care to patients at a reasonable cost.

Another widespread criticism of nursing schools, associations, and boards is that the effort to raise the educational requirements for pupil nurses has been pushed too fast and too far. In all fairness, however, it must be said that the road travelled by the nursing profession has been a long and ever broadening one. The leaders have tried to keep nursing education abreast of the rapidly advancing front in medical knowledge. They have recognized the increasing complexities of scientific medicine and have insisted on higher and still higher qualifications for the young woman who wanted to study nursing. They have expanded and increased the number of didactic courses in the curriculum of the pupil nurse. They have encouraged universities to foster schools of nursing. They have pressed for the goal of a college degree as a prerequisite for nurses' training. This laudable effort has much to commend it, but there are at least two undesirable consequences that make it imperative for the leaders in nursing education to pause and take their bearings. These unfortunate results are: first, the failure of this program to attract and to hold an adequate number of young women to meet the needs of the country; and second, the nurse of today is not being trained primarily to care for the patient. The situation in the field of education of nurses poses a dilemma for the leaders. Medicine is becoming increasingly complex, hence the need for more and more education, but each additional didactic course in the curriculum leaves less time for the pupil nurse to learn bedside care.

It seems clear that the kernel of this problem lies in the failure of the directors of nursing to devise ways of passing along part of the nurses' work to subordinates. In the practice of medicine this is being done constantly. A fitting illustration is the matter of transfusions. Thirty-five years ago a blood transfusion was considered a surgical procedure, and was performed in the operating room by a surgeon with two assistants. Then, as the indirect method was perfected, transfusions were entrusted to a resident and were carried out in the patient's room. Later, the interne took over, and now in many hospitals the blood is matched in the blood bank and the transfusion is given by a nurse. Directors of nursing policies have been so intent on increasing the educational content of the curriculum that they have not devised ways of providing trained personnel to relieve the graduate nurse of unimportant tasks. Probably eighty per cent of the actual nursing care of the average patient can be done by high

school graduates who have had a short period of practical training. It is equally true, however, that there are seriously ill patients, and also there are administrative positions, that require highly intelligent, highly educated nurses.

The final complaint that was noted at the beginning of this article has to do with one of the intangibles—a loss of *esprit de corps*. This is reflected in the feeling of many nurses that they are no longer participants in a profession, but merely employees. The doctors are largely to blame for this condition. The leaders in nursing are partly to blame for they have neglected the graduates and in some institutions catered to the cadet nurses with great partiality. All of us have been too busy during the War to give much time or thought to the nurses, but the war is over now and every surgeon worthy of the name should make a real effort to win back the enthusiasm and good will of the nurses with whom he works.

It is not the intention of this writer to make definite recommendations for the solution of the difficulties that have been considered. It would be presumptuous for any single person to do so. The correction of these problems is primarily the responsibility of the leaders in nursing. To assist these leaders is an obligation of every doctor. The schism that has developed between the nursing and medical professions is not irremediable; it can be closed. It is imperative that steps be taken to do so. In fact, the present situation offers a wonderful opportunity for intelligent leadership to perfect the integration of the two professions. Let us then critically examine the conditions in our own community and seek the solution of our mutual problems with courage, common sense, and, above all, in a spirit of good will. W. M. Firor.

STONEWALL JACKSON GOING FORWARD ON THE PLANK ROAD IN ADVANCE OF HIS LINE OF BATTLE.

THE SURGEON'S LIBRARY

THE BOOK SHELF

SHENANDOAH TRAGEDY

WILLARD BARTLETT, A.M., M.D., D.Sc., St. Louis, Missouri

MY own compelling interest in Thomas J. "Stonewall" Jackson and the tragedy of 1863 was aroused by a visit to General Custis Lee, brother of the great leader, at Lexington, Virginia, when he was president of Washington and Lee University. A young friend and I had just graduated from college when we decided to ride our bicycles from Central Illinois to the Shenandoah Valley and explore that historic region which had been soaked with the best of Southern and Northern blood. It was just twenty-nine years after the unspeakable misfortune of which I write, an event which may have determined the outcome of the war, one which certainly shook the military world.

The little city of Lexington seemed very lovely that summer day when General Lee, a stately gentleman just past middle life, took me up to the Virginia Military Institute for one of the most stimulating experiences of my life. We stood in the class room in which Jackson had taught during the ten years which preceded the secession; I shall never forget Lee's recital of the incident of cadet impatience to be off as soon as war had been declared. The teacher is said to have cautioned them against haste, then to have offered to lead them when the proper time arrived, at which the fifteen year old boys screamed with merriment on hearing such war-like words from their always moderate and peace-loving teacher. When the proper time came he *did* lead them marching away bravely together, the cadets to graves in the Valley, the leader to that Valhalla which is the eternal home of all heroes.

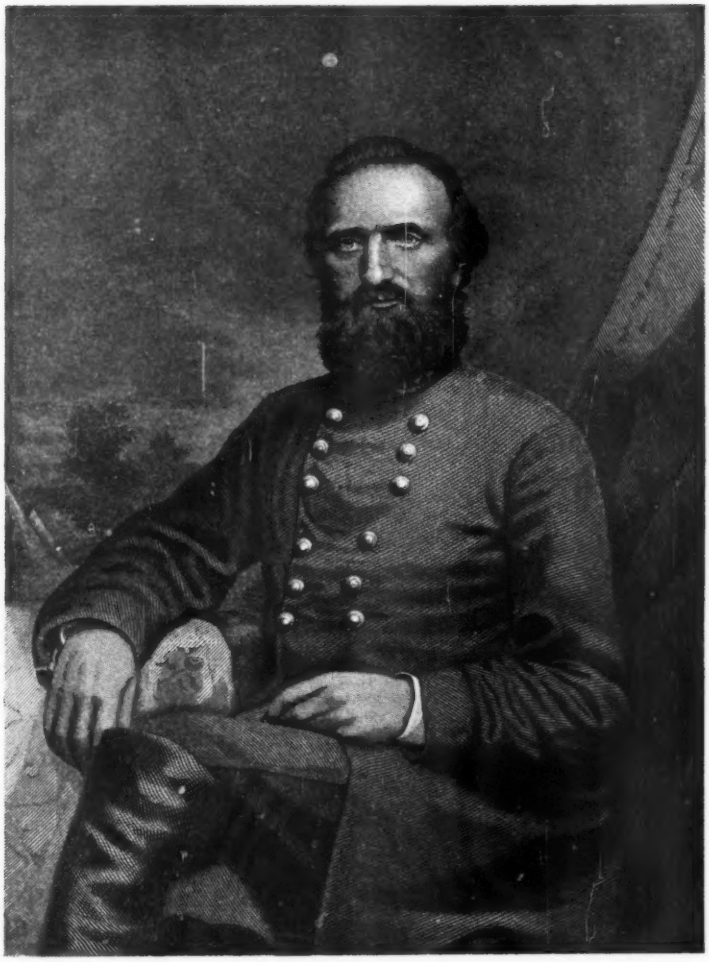
Thomas J. Jackson was born in Clarksburg, West Virginia (a part of Virginia itself until it seceded) on January 21, 1824. He was orphaned at seven; grew up on a farm; was appointed to West Point at the age of eighteen though his preparatory education had been poor, he never having reached a highschool grade. He graduated at West Point in 1846; took part in General Scott's campaign from Vera Cruz to Mexico City; was twice brevetted for good conduct; later had army duty at Fort Hamilton, New York, and Fort Meade, Florida. He resigned from the army in 1851; then taught philosophy and artillery tactics for ten years at Virginia Military Institute. He was an earnest member of the Presbyterian church, was greatly interested in slaves and conducted a Sunday school for them.

Jackson was a tall, spare man with a full beard, singularly handsome but a man of few words. He was twice married, first to Miss Eleanor Junkin and secondly to Miss Mary Ann Morrison.

A few days after the secession of Virginia General Jackson took over command of the troops at Harper's Ferry; a few weeks later he became commander of a brigade and remained one until Bull Run where he acquired the title "Stonewall." There he was made Major General. In November of 1861 he took command of the Shenandoah Valley and that portion of Virginia northwest of it, his specialty being rapid movements against one enemy, then another, keeping them all bewildered. In December, 1862, he was advanced to the rank of Lieutenant General, commanding the right wing of the Confederate Army.

The campaigns which brought him most fame seem to have been Bull Run, Richmond, Manassas, Harper's Ferry, Antietam, and Chancellorsville. This brilliant tactician lived but thirty-nine years, as it happened, because on May 1, 1863, Lee ordered him to attack Hooker at Chancellorsville, causing the latter to withdraw into the wilderness to establish new lines. Next day he was early again on the march and highly successful; then between eight and nine o'clock of that moonlight Saturday evening he rode forward to reconnoiter, but when returning his party was mistaken for Federal troops and was fired on by the 18th North Carolina regiment of Lane's brigade, the General receiving wounds that proved fatal eight days later.

Dr. Bartlett is professor emeritus of clinical surgery, Washington University School of Medicine.



THOMAS JONATHAN JACKSON
1824–1863

One bullet entered the right hand, two the left arm, the latter cutting the brachial artery and shattering the humerus. The General's horse plunged beneath the limb of a tree which struck the rider in the face, but one of his officers caught the reins and the wounded man fell into his arms. Companions took off his blood soaked garments and tried to bandage the wounds, while others sought Surgeon General McGuire of the Stonewall brigade who was nearby. Jackson was bleeding and in great pain, supported by officers on each side, while shells and bullets flying about threw men, officers, and riderless horses into complete disorder. He was undismayed, however, though bleeding profusely and deathly pale when he issued his last order, "Pender must hold out to the last." He begged to lie down so a litter was made, but when one of the bearers of it fell the General pitched to the ground incurring a fresh serious injury to his chest.

McGuire, who had found him by moonlight coming through the trees, met him with an am-

bulance. The General was still bleeding profusely though he remained calm, self-controlled, and expressed sympathy for others. McGuire placed his finger on the left brachial artery and held it there during the ride in the ambulance, during which time whiskey and morphine were administered. Two and one-half hours after the wounding McGuire made an examination. Then by two o'clock Sunday morning in a hospital Jackson, under blankets, again got whiskey and water. A little later chloroform was given after which a bullet was taken from his right hand which had been fractured and his left arm was amputated high, entailing a simple, quick, bloodless circular operation. The other bullet had entered the outside of his forearm just below the elbow to come out the opposite side above the wrist. The few slight face wounds were dressed; then the General delegated authority to General Stuart, after which he slept several hours.

Monday morning he was free from pain and hopeful; some hours later he suffered right chest pain resulting, according to the Surgeon General, from the litter fall though no lesion was discovered and this pain was gone a few hours later. Tuesday morning he was removed in the ambulance and arrived at the Chandler House about 8:00 p.m. where he died five days later. He ate fairly well after his arrival, slept the entire night and on Wednesday was thought to be improving. He felt well, was cheerful, had his wounds dressed and then asked *when he could return to battle.* At daylight Thursday, however, he was in great pain and McGuire found a right pleural pneumonia. *Cupping, mercury, antimony, and opium* were employed. His wife arrived then and nursed him to the end. All wounds were dressed Friday, he breathed with difficulty, there also was great exhaustion. On Sunday morning, May 10, 1863, his wife told him that recovery was doubtful; he then expressed his wish to be buried in Lexington after stating that he had hoped that some Sunday would be his last day on earth. Then his mind began to wander and he gave murmured army commands, his last words being, "Let us cross over the river and rest under the shade of the trees."

The remains were taken to Richmond for a public funeral, then to Lexington for burial. In 1875 a bronze monument was erected to his memory in Richmond, it having been paid for wholly by English subscribers who greatly admired this American military genius.

Eighty-three years have now elapsed since Jackson's wounding. It is only natural that we surgeons of three generations should entertain a composite opinion of surgical thought as it has developed since that time and speculate on the treatment and prognosis in a like accident as of today. (None of this is to be taken as hypercritical since Hunter McGuire was a distinguished surgeon whose son, Stuart, I am proud to claim as a friend.)

We must consider hemorrhage, early amputation, anesthetic, asepsis, systemic antiseptics, and information regarding impending death.

1. Hemorrhage left the Civil War surgeon helpless as far as *replacement* therapy was concerned; indeed, its *control* was limited to pressure, cautery, ligation, or amputation.

2. Today it is considered unlikely that gangrene will follow destruction of the brachial artery, particularly if a paravertebral block dilates the collaterals. Surely prolonged observation of the ischemic arm previous to amputation would be justified, particularly after profuse bleeding and shock.

3. Chloroform, though admittedly dangerous, was of course the accepted anesthetic of the period. A form of nerve block today would take its place and at the same time centripetal shock impulses would be prevented from reaching the already damaged nerve centers.

4. The Civil War was over long before the thought or practice of antisepsis or asepsis reached America from its European birthplace. I heard my own father some twenty years later enthuse frequently over the appearance of *laudable pus after amputations.*

5. The pneumonia, which was apparently "the last straw," today could have been easily controlled by sulfonamides, I suppose, if not almost certainly by penicillin. Systemic antiseptics had not been dreamed of in 1863.

6. Today we are not given to warning the patient of impending death, so one fails to see how the General's chances of recovery were enhanced by frequent depressing messages on this subject from many of the group about him.

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REVIEWS OF NEW BOOKS

THE small volume *Cancer of the Scrotum in Relation to Occupation*[1] by Henry puts on record observations of the author which may indicate that certain specific agents are, under industrial conditions, the main factors in the production of scrotal epithelioma. Cancer of the scrotum contributes less than 8 per cent of all deaths caused annually by cancer of the skin and only 0.25 per cent of all the deaths caused by cancer of all sites.

Percival Potts in 1775 quoted from Ramazini's book, *De Morbis Artificum* giving him credit for the first reference to chimney sweepers' cancer. He also stated that "cancer of the scrotum and testes is a lesion or disease to which chimney sweepers are peculiarly liable." In addition Potts felt that soot workers were more susceptible to scrotal ulceration or carcinoma. A high incidence of cancer of the scrotum among industrial workers of certain trades, as cotton mule spinners, was observed by Wilson in 1910. Carcinoma or ulceration of the skin occurring in chimney sweepers, or workers handling pitch tar, or tarry compounds received statutory recognition in 1907 and was added to the 3rd schedule of the Workmen's Compensation Act. Cutaneous epitheliomas occurring in workers coming in contact with mineral oil, paraffin, or their residue was made compensible in 1914.

The Factories Act of 1920 made epitheliomatous ulceration of the skin a reportable disease. From 1920 to 1943, 3,333 cases were reported of which 1,355 or 40.6 per cent were scrotal lesions. The percentages of scrotal lesions reported in the following industries were: coke oven workers, 47.6 per cent, coal gas workers, 31.6 per cent, tar distillery workers, 19.8 per cent, and pitch workers, 16.4 per cent. It was further found that 1,296 or 38.8 per cent of 3,333 notifiable cutaneous cases occurred in the cotton trade (cotton mule spinners) resulting from contact with mineral and shale oil. Seven hundred and ninety-three or 64.5 per cent of the scrotal lesions were reported in the cotton mule spinner workers.

The mortality rate of 1,638 cases of scrotal malignancy between 1911 and 1938 was 4.2 per million population or 58 per cent. In addition, it was found that cutaneous carcinoma following the commencing of occupational work occurred after 49 to 50 years. In the case of cotton mule spinners, the lag period varied from 15 to 35 years, 1 case occurred after 65 years. The average death age in 163 cases was 61.6 years. It was, however, impossible to make any deductions of value because so many factors influence the death age. The different ages an employee would enter his occupation, the changing of occupations, the unknown carcinogenic substances in new industries make the information obtained from the death age regarding the time it takes for the carcinogenic substances to act most unreliable.

The treatment recommended for scrotal carcinoma was local excision or radiotherapy. Removal of the inguinal glands was recommended as a "wait and see" policy because many of the palpable inguinal glands are only inflammatory. Deep therapy caused loss of fewer work days but had the disadvantage of not permitting a biopsy. In a series of 155 patients with primary scrotal malignancies, 93 of 60 per cent died of metastases within 2 months to 4 years with or without operation (some refused surgery).

Some suggestions were made regarding the prevention of carcinogenic substances from reaching the body of the worker. Also quarterly or biannual physical examinations would pick up scrotal cancer cases much earlier. Some workers dislike to report genital sores or lesions. Cleanliness, adequate ventilation, protective clothing and baths were recommended as prophylatic measures. Early treatment offers the best hope of cure. LEANDER W. RIBA.

THE contributions of the frontier military surgeon, William Beaumont, to the physiology of digestion are a source of pride to every American surgeon. He was our first great physiologist and the first to make a contribution of enduring value. His work with Alexis St. Martin is well known and his own records of those classical experiments have been made readily available by a recent reprint. The present book *William Beaumont's Formative Years*[2] consists of two diaries kept by Beaumont, the one recording his medical observations and experiences, and the other excerpts from his general reading and glimpses of his own philosophy. They cover the period immediately preceding his arrival at Mackinac Island and provide an interesting picture of his activities as a military surgeon during the not too glorious War of 1812. The quotations from the medical authors admired by Beaumont provide the reader with a graphic picture of the scientific fare that was available to the backwoods surgeon and scientist and as a result his own contribution shines the more brightly. Every physician who admires scholarship should read this book. LESTER R. DRAGSTEDT.

[1] CANCER OF THE SCROTUM IN RELATION TO OCCUPATION. By S. A. Henry, M.A., M.S. (Cantab.), F.R.C.P., D.P.H. (Cantab.). London, New York, Toronto: Oxford University Press, 1946.

[2] WILLIAM BEAUMONT'S FORMATIVE YEARS. Two Early Notebooks 1811–1821. With Annotations and an Introductory Essay by Genevieve Miller, M.A. New York: Henry Schuman, 1946.